Sequence 7: movement

Fiche de synthèse mobilisée (collection en français) :

– Fiche n°7 : mouvements : position, vitesse, accélération

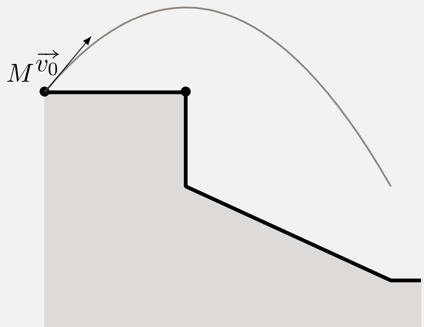
Sommaire des activités ETLV :

ACTIVITY 1: Acceleration of a pinguin

Objective: computing speed and acceleration at a given position

DOCUMENT 1: Movement of the pinguin

A pinguin jumps off a cliff with an initial speed. His movement is observed, and his position is referenced versus time.



Source: Wikimedia commons

DOCUMENT 2: Position and time

His position, of coordinates x and y, is entered using the code Python:

```
x = [0.,0.28, 0.56, 0.85, 1.13, 1.41, 1.70, 1.98,
    2.26, 2.54]
y = [10.0, 10.22, 10.32, 10.30, 10.16, 9.90, 9.51,
     9.01, 8.39, 7.64]
```

Time is also coded as a list:

```
t = [0. , 0.11, 0.22, 0.33, 0.44, 0.55, 0.67,
    0.78, 0.89, 1.  ]
```

```
N = len(x) #number of values
```

DOCUMENT 3: Computing speed

Each position can be referred to using indexes: for example, x[i] and y[i] at index i and x[i+1] and y[i+1] at index i+1.

Speed at index i can be computed using:

$$v_x[i] = \frac{x[i+1] - x[i]}{t[i+1] - t[i]} \quad \text{and} \quad v_y[i] = \frac{y[i+1] - y[i]}{t[i+1] - t[i]}$$

Careful: vx[N-1] and vy[N-1] cannot be computed as x[N] and y[N] do not exist. Indeed, indexes stop at N-1.

DOCUMENT 4: Computing acceleration

Each speed coordinate can be referred to using indexes: for example, vx[i] and vy[i] at index i and vx[i+1] and vy[i+1] at index i+1.

Acceleration at index i can be computed using:

$$a_x[i] = \frac{v_x[i+1] - v_x[i]}{t[i+1] - t[i]} \quad \text{and} \quad a_y[i] = \frac{v_y[i+1] - v_y[i]}{t[i+1] - t[i]}$$

Careful: ax[N-2] and ay[N-2] cannot be computed as vx[N-1] and vy[N-1] do not exist.

DOCUMENT 5: Computing speed and acceleration using Python

```
vx=[]
vy=[]
for i in range(0,N-1):
    vx.append((x[i+1]-x[i])/(t[i+1]-t[i]))
    vy.append((y[i+1]-y[i])/(t[i+1]-t[i]))

ax = []
ay = []
for i in range(0,N-2):
    ax.append((vx[i+1]-vx[i])/(t[i+1]-t[i]))
    ay.append((vy[i+1]-vy[i])/(t[i+1]-t[i]))
```

Understanding and applying:

Which mathematical expressions are used in order to compute speed coordinates v_x and v_y (using x and y)?

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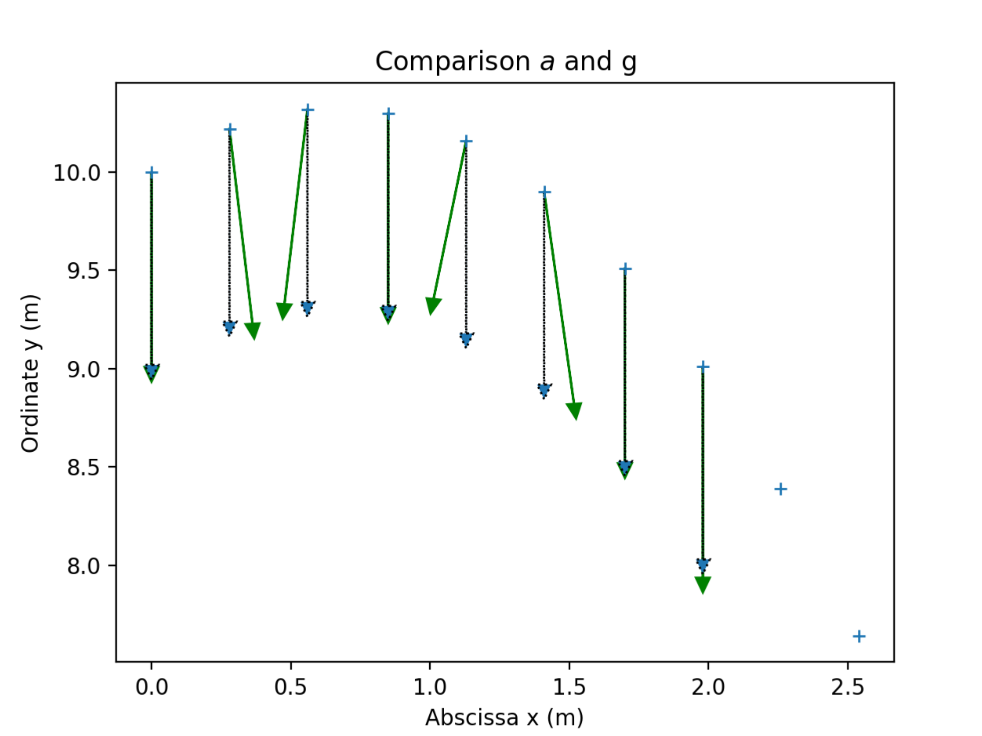
Which mathematical expressions are used in order to compute acceleration coordinates a_x and a_y (using v_x and v_y)?

____

DOCUMENT 6: Plotting acceleration



Reinvesting, going further:

In the above graph, acceleration vectors $\vec{a}$ are plotted in green at each position of the pinguin. Gravitational acceleration $\vec{g}$ vector is also plotted in blue. Could there be a relationship between $\vec{g}$ and $\vec{a}$?

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In your opinion, why are vectors not plotted at the last two positions of the pinguin?

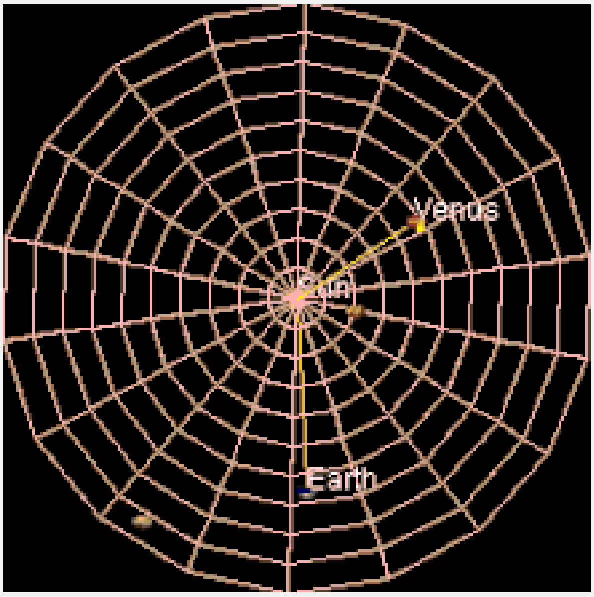
____

ACTIVITY 2: Movement of Venus

Objective: computing speed and acceleration at a given position

DOCUMENT 1: Orbit and rotation of the planet Venus

Venus orbits the Sun at an average distance of about 0.72 AU (108 million km) and completes an orbit every 224.7 days. Although all planetary orbits are elliptical, Venus's orbit is currently the closest to circular.



Venus is the second planet from the Sun, orbiting approximately 1.6 times (yellow trail) in Earth's 365 days (blue trail).

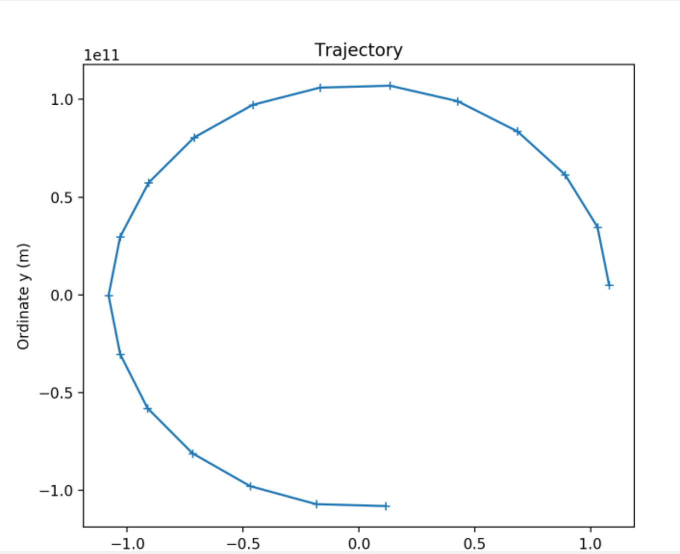
Source: Wikipedia

DOCUMENT 2: Partial trajectory of the planet Venus

The trajectory of Venus in a heliocentric referential is plotted below using Python. x and y coordinates are given in meters:

```
x=[1.08E+11, 1.03E+11, 8.90E+10, 6.85E+10, 4.26E+10, 1.34E+10,
-1.68E+10, -4.58E+10, -7.11E+10, -9.07E+10, -1.03E+11, -1.08E+11,
-1.03E+11, -9.12E+10, -7.18E+10, -4.69E+10, -1.84E+10, 1.16E+10,
4.06E+10, 6.66E+10]
y =[5.19E+09, 3.47E+10, 6.15E+10, 8.36E+10, 9.91E+10, 1.07E+11,
1.06E+11, 9.72E+10, 8.05E+10, 5.74E+10, 2.97E+10, -2.90E+08, -3.03E+10,
-5.79E+10, -8.10E+10, -9.78E+10, -1.07E+11, -1.08E+11, -1.01E+11,
-8.61E+10]
```

Measurements were taken every 10 days.



Understanding and applying:

What type of movement seems to apply?

___

How many days seem necessary to complete the full orbit? Is this a realistic value (see document 1)?

___

What is roughly the radius of the orbit? Is this realistic?

___

DOCUMENT 3: Computing speed

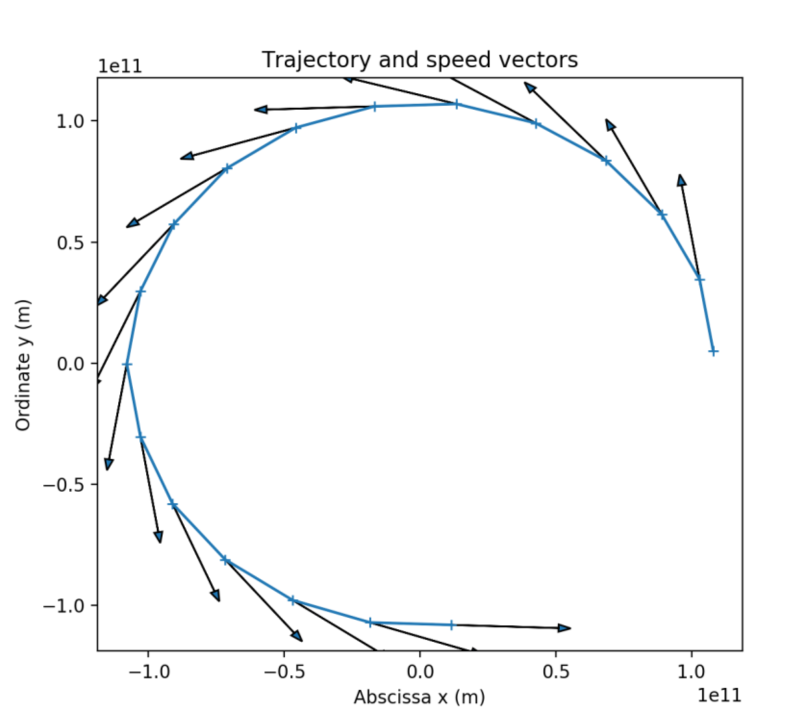
Each position can be referred to using indexes: for example, x[i] and y[i] at index i and x[i+1] and y[i+1] at index i+1.

Speed at index i can be computed using:

$$v_x[i] = \frac{x[i+1] - x[i]}{t[i+1] - t[i]} \quad \text{and} \quad v_y[i] = \frac{y[i+1] - y[i]}{t[i+1] - t[i]}$$

Careful: vx[N-1] and vy[N-1] cannot be computed as x[N] and y[N] do not exist. Indeed, indexes stop at N-1.

DOCUMENT 4: Plotting speed vectors



Understanding and applying:

How are speed vectors oriented?

____

DOCUMENT 5: Computing acceleration

Each speed coordinate can be referred to using indexes: for example, vx[i] and vy[i] at index i and vx[i+1] and vy[i+1] at index i+1.

Acceleration at index i can be computed using:

$$a_x[i] = \frac{v_x[i+1] - v_x[i]}{t[i+1] - t[i]} \quad \text{and} \quad a_y[i] = \frac{v_y[i+1] - v_y[i]}{t[i+1] - t[i]}$$

Careful: ax[N-2] and ay[N-2] cannot be computed as vx[N-1] and vy[N-1] do not exist.

In Python these values are computed:

```
ax = []
ay = []
for i in range(0,N-2):
    ax.append((vx[i+1]-vx[i])/(t[i+1]-t[i]))
    ay.append((vy[i+1]-vy[i])/(t[i+1]-t[i]))

a = []
for i in range(0,N-2):
    a.append(np.sqrt(ax[i]**2+ay[i]**2))
```

DOCUMENT 6: Values of acceleration

```
a = ([0.01259103, 0.01074516, 0.01142351, 0.01109923, 0.01199739, 0.01057175,
0.01168597, 0.0114807, 0.01155859, 0.01024889, 0.01339595, 0.0096644, 0.01183171,
0.01120303, 0.01126532, 0.01116693])
```

The average value for acceleration is: $a = 0.013\ m.s^{-2}$

What can be said about acceleration values?

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Activity summary

What you must remember:
- speed
- acceleration
- plotting
- abscissa
- ordinates

Skills linked to the curriculum**:**

Compétences	Capacités à maîtriser	Où dans cette séquence ?
APP	• Utiliser du vocabulaire spécifique	Activités 1 et 2
	Lire et comprendre des documents scientifiques	Activités 1 et 2
ANA	Mettre en lien des documents pour émettre des hypothèses en réponse à une question scientifique	Activité 2
COM	S'exprimer à l'écrit en utilisant le vocabulaire adapté	Activités 1 et 2
REA	• Citer et exploiter la relation entre les coordonnées du vecteur vitesse et celles du vecteur accélération. • Capacité numérique : utiliser un tableur, un logiciel ou un programme informatique pour calculer : les cordonnées des vecteurs vitesse et accélération à partir des cordonnées des positions dans le cas d'un mouvement plan ;	Activité 2