Kinematics 1D

10060
Physics

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Position, tid, gennemsnitshastighed

Hastighed:

$$v = \frac{x_2 - x_1}{t_2 - t_1} \tag{1}$$

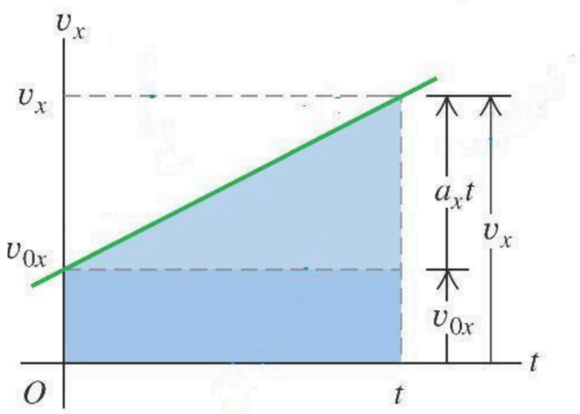
Fart:
Fart er $|v|$

Instantan hastighed

Kan få hastighed ved af differentiere en position over tid grad.

På sådan en grad kaldes det en *sekant* hvis den forbinder to punkter, og en tangent hvis det kun er ét punkt.

- Instantan hasitghed: $v_x = \frac{dx}{dt}$
- Gennemsnitshastighed: $\overline{a_x} = \frac{\Delta v_x}{\Delta t}$
- Instantan acceleration: $a_x = \frac{dv_x}{dt} = \frac{d^2x}{dt^2}$



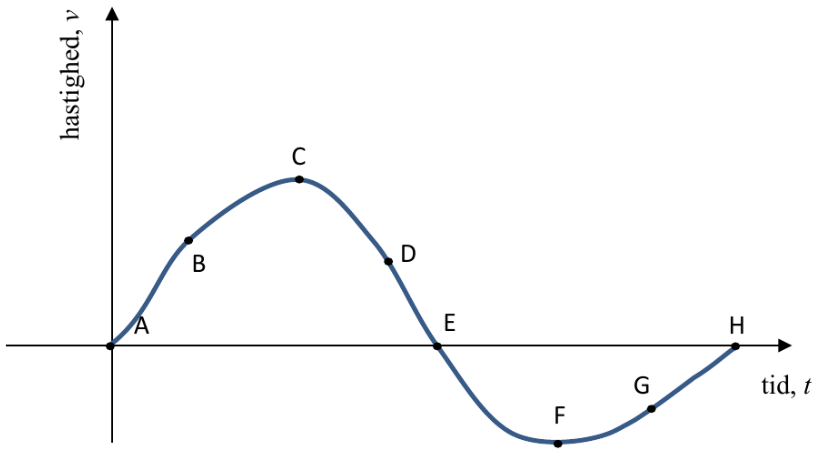
- Lineær sammenhæng i tid: $v_x = v_{0x} + a_x \cdot t$
- Gennemsnitshastighed: $\overline{v} = \frac{v+v_0}{2}$

- $v = v_0 + at$
- $x = x_0 + v_0 t + \frac{1}{2}at^2$
- $v^2 = v_0^2 + 2a(x - x_0)$
- $x - x_0 = \frac{v_0+v}{2}t$

Opgaver

Problem 1

A researcher study wild wolves in Jutland. A certain wolf is captured and equipped with a GPS tracker, so that the researcher can follow the motion of the wolf. The graph below shows the velocity of the wolf as a function of time as it travels on a straight path through the woods.



In which if the marked points (A-H) does the wolf not move?

A) Only E
B) A, E and H
C) C and F
D) None of the marked points, the wolf is constantly moving.
E) Don't know

In which of the marked points (A-H) does the wolf not accelerate?

A) Only E
B) A, E and H
C) C and F
D) In all points, the wolf never accelerates
E) Don't know

In which time intervals does the wolf approximately move at constant acceleration?

A) A-B
B) B-C
C) D-E and G-H
D) C-D and E-F
E) B-C and F-G
F) Don't know

At what time is the wolf furthest away from the starting point at $t = 0$ s?

A) C
B) E

C) F
D) H
E) Don't know

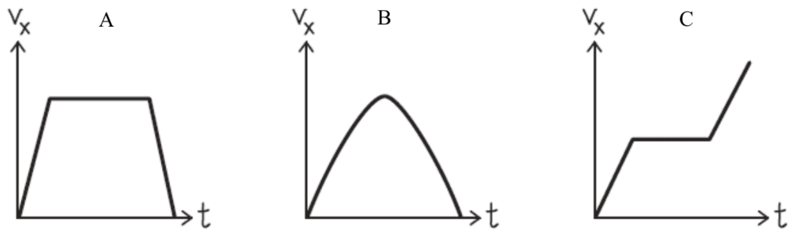
Solution:

B), **C)**, **C)**, **B)**

Problem 2

A particle starts from rest and moves rightward direction. Below, the position of the particle is shown at different points in time. The time interval between each point is the same for all points.

Below, three different graphs (A, B and C) shows the velocity of a particle as a function of time.



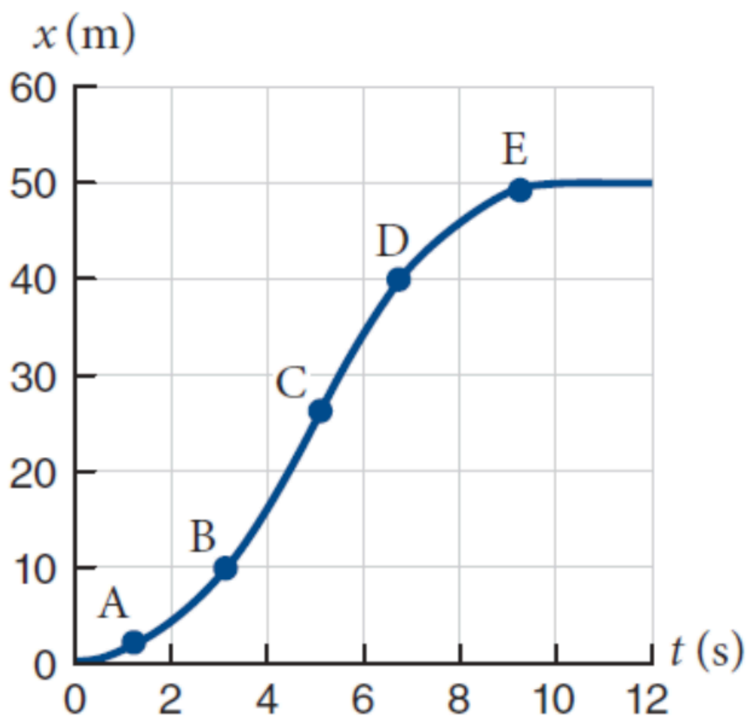
Which of the graphs fits with the motion of the particle?
A) A
B) B
C) C
D) None of the graphs fits the motion of the particle
E) Don't know

Solution:

A) fordi at der er samme mellemrum mellem de midterste punkter. Så der må hastigheden være den samme.

Problem 3

The graph below shows the position of a car as a function of time. Five points is denoted A-E.



In which points (A, B, C, D and/or E) does the car slow down?

A) A
B) B
C) C
D) D
E) E
F) This answer cannot be solved using the graph
G) Don't know

Solution:

D) og **E)** fordi tangenthældningen bliver mindre i de to punkter.

Problem 4

The largest braking acceleration for a car on a dry when road is $8\frac{m}{s^2}$. Two cars are driving towards each other with $88\frac{km}{h}$ and the drivers brakes when they are $85m$ apart

a) Will the two cars crash?
b) In case the cars crash, what are the relative velocity of the cars in the crash?
c) In case the cars do not crash, how far are they apart when they come to a stop?
d) Sketch the distance as a function of time for both cars in the same coordinate system.

Solution:

a) No

$88\frac{km}{h} \approx 24.4\frac{m}{s}$ Will take them ~ 3 seconds to brake

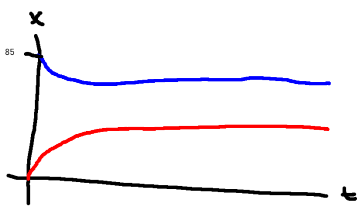
For first driver: $x = x_0 + v_0 t + \frac{1}{2} a t^2 \Leftrightarrow x = 0 + 24.4\frac{m}{s} \cdot 3s - \frac{1}{2} \cdot 8\frac{m}{s^2} \cdot 3s \approx 37.3$

Since this is under half the distance, they will not crash. See Maple document for full math

b) Not relevant

c) It's around 10.3 meters between them. It's how long car 1 is to halfway point times 2 (because they have same speed and same acceleration).

d)



Problem 5

Two identical cars are driving towards each other with a speed of $50.0\frac{km}{h}$. When there is 100 meters between, each car brakes with a constant acceleration of $5\frac{m}{s^2}$.

Which of the following statements are correct?

A) They stop when they are 17.6 meters from each other
B) They stop when they are 61.4 meters from each other.
C) They stop when they are 80.7 meters from each other.
D) They stop just in front of each other.
E) They crash after 1.06 seconds.
F) They crash after 18.9 seconds.
G) They stand still after 1.14 seconds
H) They stand still after 2.78 seconds
I) Don't know.

Solution:

B) and **H)** are true. See Maple

Problem 6

A car is driving on a horizontal straight road with $95\frac{km}{h}$. The driver observes a pedestrian crossing the road 60 meters in front, and tries to avoid a collision by breaking the car. The driver has a reaction rate of $1.5s$ before he brakes. During braking, the acceleration is $8.0\frac{m}{s^2}$

When the car reaches the pedestrian:

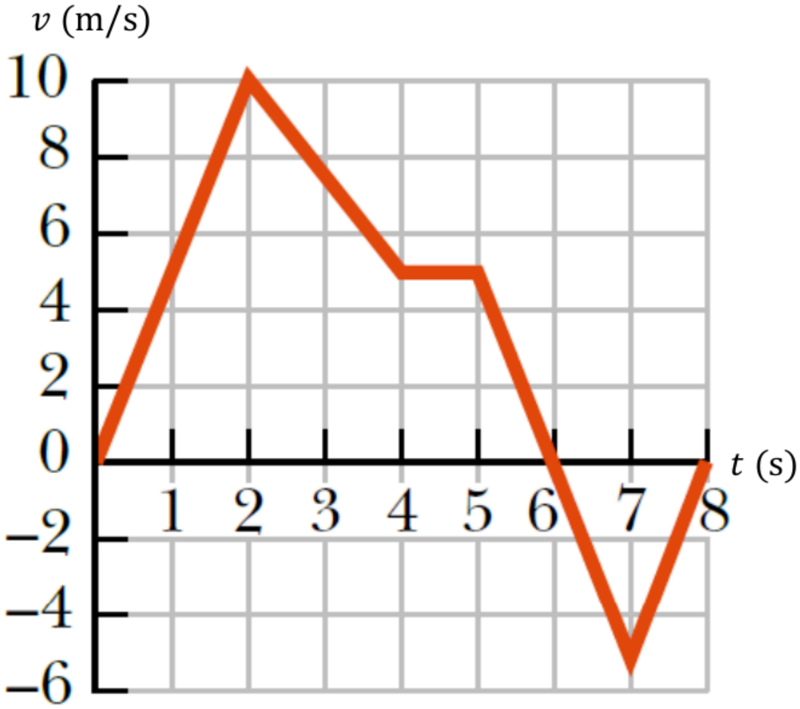
A) It has a speed of $0.0\frac{km}{h}$ (It just manages to stop)
B) It has a speed of $69\frac{km}{h}$
C) It has a speed of $93\frac{km}{h}$
D) It does not reach the pedestrian
E) Don't know

Solution:

B)

Problem 7

The graph below shows the velocity of a particle in a time interval from $t = 0s$ to $t = 8s$.



Which of the following statements are true?

A) The position of the particle is greater at $t = 8s$ compared to $t = 0s$
B) The particle does not at any point move with a speed greater than $5\frac{m}{s}$
C) From $t = 0s$ to $t = 4s$ the particle has moved $20m$
D) At a given time interval, the particle moves $5m$ in negative direction.
E) During the motion, the particle has an acceleration of $+5\frac{m}{s^2}$ and $-5\frac{m}{s^2}$
F) Between $t = 4s$ and $t = 5s$ the particle is at rest.
G) Don't know

Solution:

A), **D)** fordi den gør det i intervallet $t = 6s$ og $t = 7s$

Problem 8

Two cars are at a stop next to each other. At time $t = 0$ the first car starts moving with constant acceleration a. At time $t = \frac{T}{2}$ the other car starts moving in the same direction as the first car with the same acceleration as the first car. How far, L, is the distance between the two cars as $t = T$?

A) $L = \frac{1}{2}aT^2$
B) $L = \frac{1}{4}aT^2$
C) $L = \frac{1}{8}aT^2$
D) $L = \frac{1}{3}aT^2$
E) $L = \frac{2}{3}aT^2$
F) $L = \frac{3}{4}aT^2$
G) $L = \frac{3}{8}aT^2$
H) $L = \frac{5}{8}aT^2$
I) Don't know

Solution:

G) because
$L = \frac{1}{2} \cdot a \cdot T^2 - \frac{1}{2}a \cdot \left(\frac{T}{2}\right)^2 = \frac{1}{2} \cdot a \cdot T^2 - \frac{1}{8}a \cdot T^2$

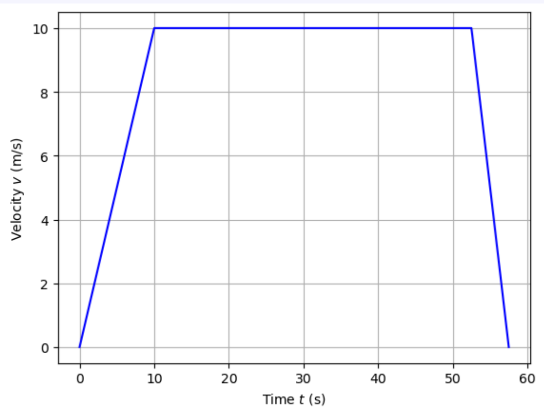
Problem 9

A RC car must travel $500m$. When accelerating, the magnitude of the acceleration of the car is $1.00\frac{m}{s^2}$. When the car is braking, the magnitude of the acceleration is $2.00\frac{m}{s^2}$. The maximum speed of the car is $10\frac{m}{s}$. The car, which must start and end at rest, has to travel the distance as fast as possible

a) Draw a graph of the velocity of the car as a function of time.
b) How long does it take the car to travel the distance?

Solution:

a)



b) 57.5 seconds

Problem 10

A boy throws a bouncy ball vertically into the ground with a speed v_0 from a height h_0. The ball does not lose energy in the collision with the ground. After the collision, the ball achieves a height h_1. The ball only moves in a vertical path.

At what speed, v_0, was the ball thrown?

A) $v_0 = \sqrt{2gh_0}$
B) $v_0 = \sqrt{2gh_1}$
C) $v_0 = \sqrt{4gh_0}$
D) $v_0 = \sqrt{2g(h_1 - h_0)}$
E) $v_0 = \sqrt{2g(h_1 + h_0)}$
F) Don't know

Solution:

D) because:

$v^2 = v_0^2 + 2 \cdot a \cdot h_0$

$0 = v^2 - 2 \cdot a \cdot h_1$

$$\begin{aligned} 2 \cdot a \cdot h_1 &= v_0^2 + 2 \cdot a \cdot h_0 \Leftrightarrow \\ v_0^2 &= 2 \cdot a \cdot h_1 - 2 \cdot a \cdot h_0 \Leftrightarrow \\ v_0 &= \sqrt{2 \cdot a \cdot h_1 - 2 \cdot a \cdot h_0} \Leftrightarrow \\ v_0 &= \sqrt{2 \cdot a(h_1 - h_0)} \end{aligned} \tag{2}$$

Problem 11

When athletes jump, it is almost like they hang in the air near the top of the motion. To understand why it looks this way, let's consider a vertical jump with height h.

a) What fraction of the jump is the athlete in the height $y > \frac{h}{2}$?

Solution:

$\frac{h}{2} = v_0 \cdot t_0 - \frac{1}{2} \cdot a \cdot t_0^2$

$$
\begin{aligned}
h &= \frac{h}{2} + v_1 \cdot (t - t_0) - \frac{1}{2} \cdot a \cdot (t - t_0)^2 \Leftrightarrow \\
h &= v_0 \cdot t_0 - \frac{1}{2} \cdot a \cdot t_0^2 + v_1 \cdot (t - t_0) - \frac{1}{2} \cdot a \cdot (t - t_0)^2 \Leftrightarrow \\
h &= v_0 \cdot t_0 - \frac{1}{2} \cdot a \cdot t_0^2 + v_1 \cdot (t - t_0) - \frac{1}{2} \cdot a \cdot (t^2 + t_0^2 - t_0 t) \Leftrightarrow \\
h &= v_0 \cdot t_0 - \frac{1}{2} \cdot a \cdot t_0^2 + v_1 \cdot (t - t_0) - \frac{1}{2} \cdot a \cdot (t^2 - t_0 t) - \frac{1}{2} \cdot a \cdot t_0^2 \Leftrightarrow \\
h &= v_0 \cdot t_0 - a \cdot t_0^2 + v_1 \cdot (t - t_0) - \frac{1}{2} \cdot a \cdot (t^2 - t_0 t)
\end{aligned} \tag{3}
$$