Fysik – lektion 1

Første lektions emner:

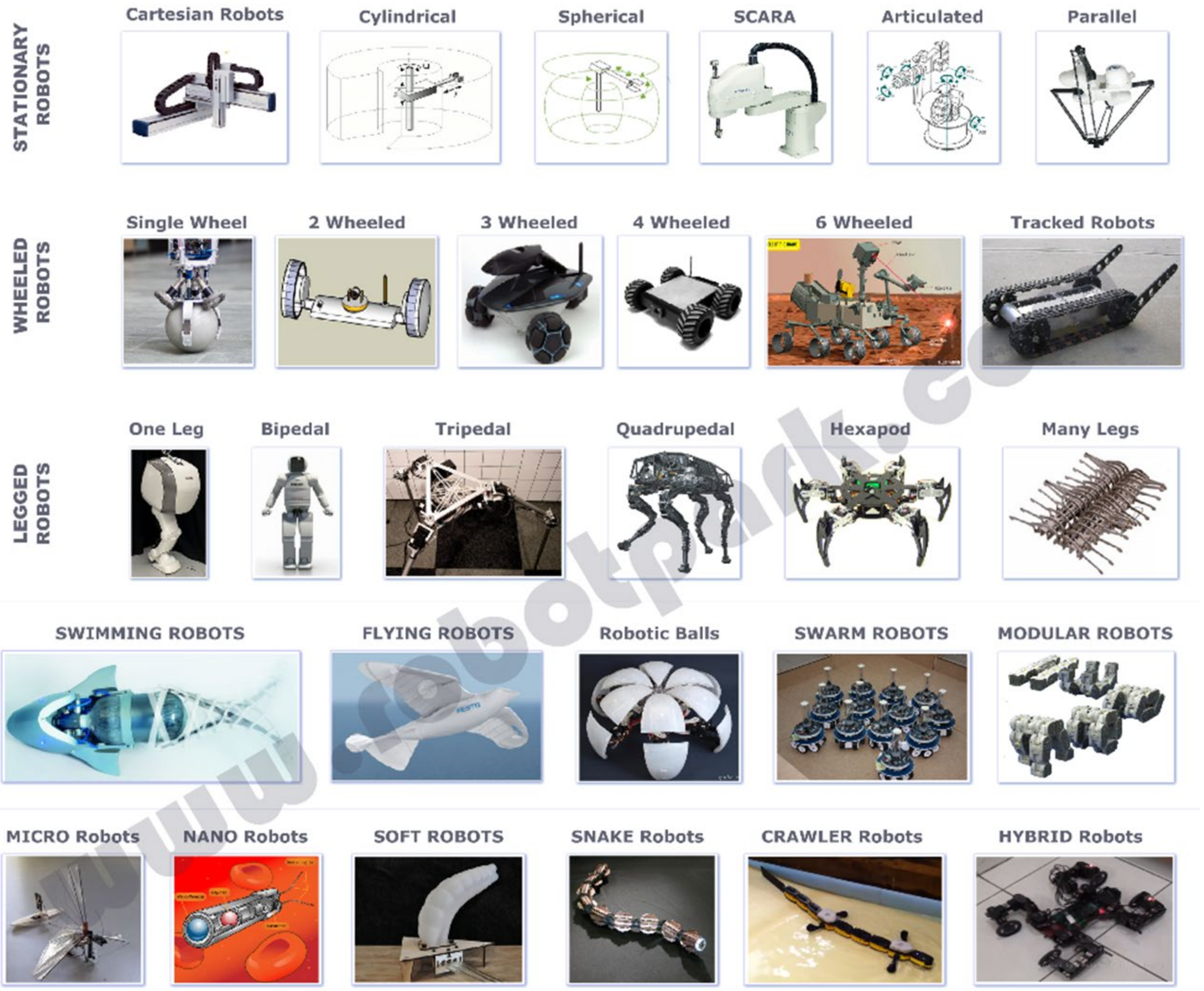
Kap. 2: Bevægelse langs en linje

Kap. 4: Bevægelse i 2 og 3 dimensioner.

- Videnskabelig metode
- SI enhedssystemet m.m.
- Middelhastighed og øjeblikshastighed
- Bevægelse med konstant acceleration – det frie fald
- Projektilbevægelsen
- Jævn cirkulær bevægelse
- Relative bevægelser
- Introduktion til lektion 2 (næste gang)
- Opgaveregning

Fysik – lektion 1

Robotingeniør og fysik ?



http://www.robotpark.com/All-Types-Of-Robots

Robotic lab assistant is 1,000 times faster at conducting research

Working 22 hours a day, seven days a week, in the dark

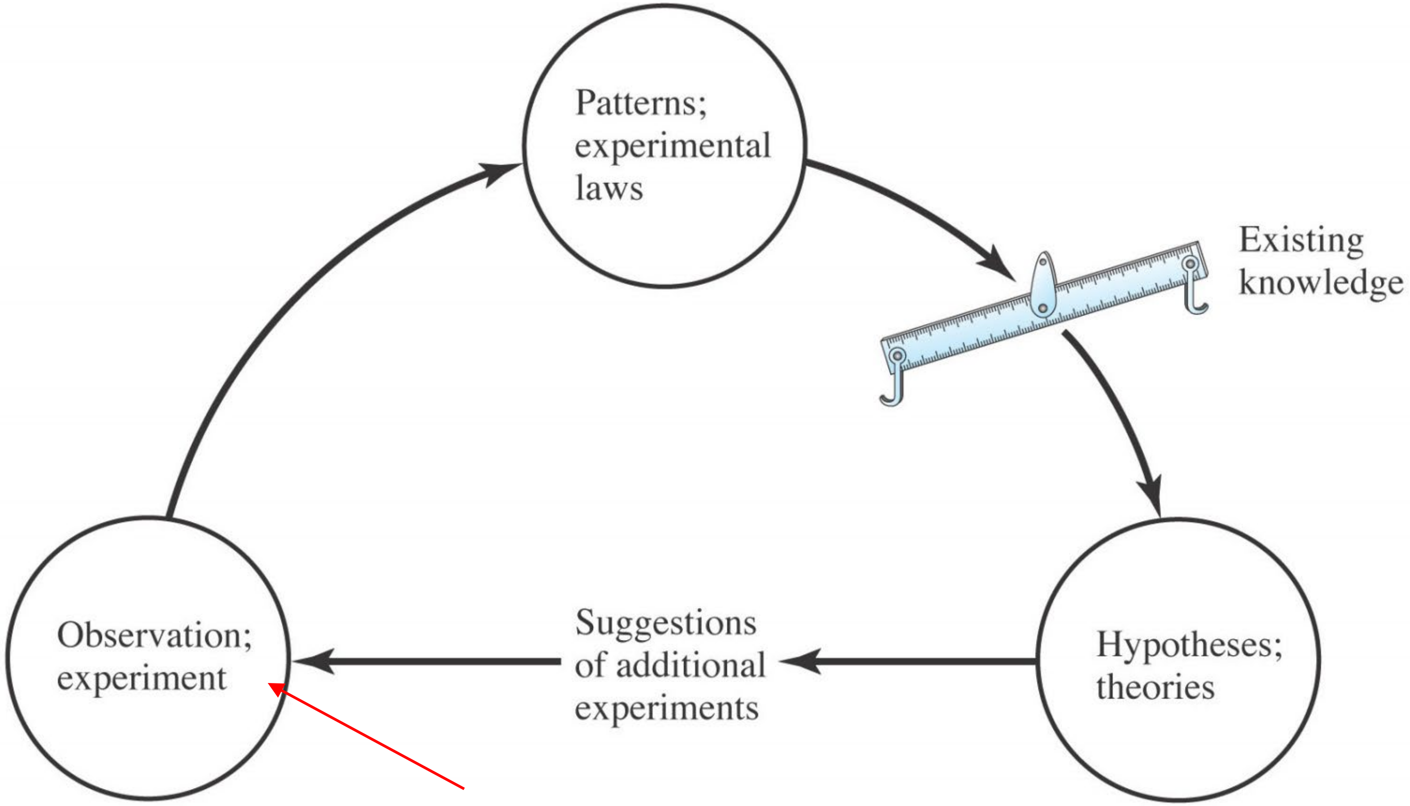
Uni. Liverpool

Robotic lab assistant, able to move around a laboratory and conduct scientific experiments just like a human

https://www.theverge.com/21317052/mobile-autonomous-robot-lab-assistant-research-speed

https://youtu.be/dRT3tepdMyI

Videnskabelig metode i naturvidenskab



Kræver målesystemer

Galileo Galilei:
Mål hvad der kan måles, og gør det måleligt, som endnu ikke er det.

SI-enhedssystemet

International standardisering af måleenheder under kontrol af:
Systéme International d'Unités

SI-enhedssystemet benyttes i det meste af verdenen undtagen USA.

7 grundlæggende SI-enheder for:	
Længde	*[meter]*
Masse	*[kilogram]*
Tid	*[sekunder]*
Elektrisk strøm	*[Ampere]*
Temperatur	*[Kelvin]*
Stofmængde	*[mol]*
Lysstyrke	*[candela]*

Plus mange andre afledte af disse syv SI-enheder!

SI-enhedssystemet

Definitionerne af enhederne i det nyligt vedtagende SI-enhedssystem er udtrykt ved

7 definerende konstanter

Konstanternes værdi er konsistent med de bedste eksperimentelle værdier til rådighed ved vedtagelsen af de nye definitioner

Defining constant	*Symbol*	*Numerical value*	*Unit*
hyperfine transition frequency of caesium	$\Delta\nu_{Cs}$	9 192 631 770	Hz
speed of light in vacuum	c	299 792 458	$m\ s^{-1}$
Planck constant	h	$6.626\ 070\ 15 \times 10^{-34}$	J s
elementary charge	e	$1.602\ 176\ 634 \times 10^{-19}$	C
Boltzmann constant	k	$1.380\ 649 \times 10^{-23}$	$J\ K^{-1}$
Avogadro constant	N_A	$6.022\ 140\ 76 \times 10^{23}$	mol^{-1}
luminous efficacy	K_{cd}	683	$lm\ W^{-1}$

SI-enhedssystemet

time	The **second**, symbol s, is the SI unit of time. It is defined by taking the fixed numerical value of the caesium frequency $\Delta\nu_{Cs}$, the unperturbed ground-state hyperfine transition frequency of the caesium 133 atom, to be 9192 631 770 when expressed in the unit Hz, which is equal to s^{-1}.
length	The **metre**, symbol m, is the SI unit of length. It is defined by taking the fixed numerical value of the speed of light in vacuum c to be 299 792 458 when expressed in the unit m s^{-1}, where the second is defined in terms of the caesium frequency $\Delta\nu_{Cs}$.
mass	The **kilogram**, symbol kg, is the SI unit of mass. It is defined by taking the fixed numerical value of the Planck constant h to be $6.626\ 070\ 15 \times 10^{-34}$ when expressed in the unit J s, which is equal to kg m^2 s^{-1}, where the metre and the second are defined in terms of c and $\Delta\nu_{Cs}$.

SI-enhedssystemet

electric current	The **ampere**, symbol A, is the SI unit of electric current. It is defined by taking the fixed numerical value of the elementary charge e to be 1.602 176 634 $\times 10^{-19}$ when expressed in the unit C, which is equal to A s, where the second is defined in terms of $\Delta\nu_{Cs}$.
thermodynamic temperature	The **kelvin**, symbol K, is the SI unit of thermodynamic temperature. It is defined by taking the fixed numerical value of the Boltzmann constant k to be 1.380 649 $\times 10^{-23}$ when expressed in the unit J K^{-1}, which is equal to kg m^2 s^{-2} K^{-1}, where the kilogram, metre and second are defined in terms of h, c and $\Delta\nu_{Cs}$.
amount of substance	The **mole**, symbol mol, is the SI unit of amount of substance. One mole contains exactly 6.022 140 76 $\times 10^{23}$ elementary entities. This number is the fixed numerical value of the Avogadro constant, N_A, when expressed in the unit mol^{-1} and is called the Avogadro number. The amount of substance, symbol n, of a system is a measure of the number of specified elementary entities. An elementary entity may be an atom, a molecule, an ion, an electron, any other particle or specified group of particles.
luminous intensity	The **candela**, symbol cd, is the SI unit of luminous intensity in a given direction. It is defined by taking the fixed numerical value of the luminous efficacy of monochromatic radiation of frequency 540 $\times 10^{12}$ Hz, K_{cd}, to be 683 when expressed in the unit lm W^{-1}, which is equal to cd sr W^{-1}, or cd sr kg^{-1} m^{-2} s^3, where the kilogram, metre and second are defined in terms of h, c and $\Delta\nu_{Cs}$.

SI-enhedssystemet

Derived quantity	Name of derived unit	Symbol for unit	Expression in terms of other units
plane angle	radian	rad	$m/m = 1$
solid angle	steradian	sr	$m^2/m^2 = 1$
frequency	hertz	Hz	s^{-1}
force	newton	N	$m\ kg\ s^{-2}$
pressure, stress	pascal	Pa	$N/m^2 = m^{-1}\ kg\ s^{-2}$
energy, work, amount of heat	joule	J	$N\ m = m^2\ kg\ s^{-2}$
power, radiant flux	watt	W	$J/s = m^2\ kg\ s^{-3}$
electric charge	coulomb	C	$s\ A$
electric potential difference	volt	V	$W/A = m^2\ kg\ s^{-3} A^{-1}$
capacitance	farad	F	$C/V = m^{-2}\ kg^{-1}\ s^4\ A^2$
electric resistance	ohm	Ω	$V/A = m^2\ kg\ s^{-3}\ A^{-2}$

Derived quantity	Name of derived unit	Symbol for unit	Expression in terms of other units
electric conductance	siemens	S	$A/V = m^{-2}\ kg^{-1}\ s^3\ A^2$
magnetic flux	weber	Wb	$V\ s = m^2\ kg\ s^{-2} A^{-1}$
magnetic flux density	tesla	T	$Wb/m^2 = kg\ s^{-2}\ A^{-1}$
inductance	henry	H	$Wb/A = m^2\ kg\ s^{-2}\ A^{-2}$
Celsius temperature	degree Celsius	°C	K
luminous flux	lumen	lm	$cd\ sr = cd$
illuminance	lux	lx	$lm/m^2 = m^{-2}\ cd$
activity referred to a radionuclide	becquerel	Bq	s^{-1}
absorbed dose	gray	Gy	$J/kg = m^2\ s^{-2}$
dose equivalent	sievert	Sv	$J/kg = m^2\ s^{-2}$
catalytic activity	katal	kat	$s^{-1}\ mol$

SI præfixer

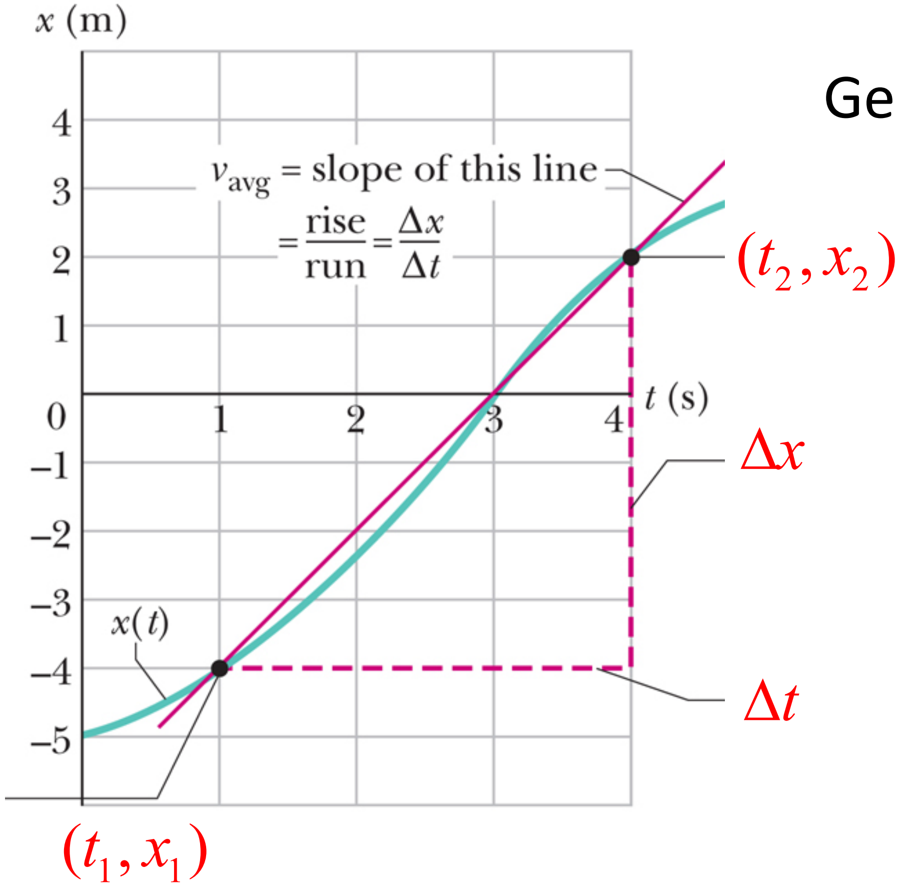
Factor	Name	Symbol	Factor	Name	Symbol
10^{1}	deca	da	10^{-1}	deci	d
10^{2}	hecto	h	10^{-2}	centi	c
10^{3}	kilo	k	10^{-3}	milli	m
10^{6}	mega	M	10^{-6}	micro	μ
10^{9}	giga	G	10^{-9}	nano	n
10^{12}	tera	T	10^{-12}	pico	p
10^{15}	peta	P	10^{-15}	femto	f
10^{18}	exa	E	10^{-18}	atto	a
10^{21}	zetta	Z	10^{-21}	zepto	z
10^{24}	yotta	Y	10^{-24}	yocto	y

Det græske alfabet

Stort	Lille	Navn
Α	α	alfa
Β	β	beta
Γ	γ	gamma
Δ	δ	delta
Ε	ε	epsilon
Ζ	ζ	zeta
Η	η	eta
Θ	θ	theta
Ι	ι	iota
Κ	κ	kappa
Λ	λ	lambda
Μ	μ	my
Ν	ν	ny
Ξ	ξ	ksi
Ο	ο	omicron
Π	π	pi
Ρ	ρ	rho
Σ	σ	sigma
Τ	τ	tau
Υ	υ	ypsilon
Φ	φ	phi
Χ	χ	chi
Ψ	ψ	psi
Ω	ω	omega

Lineær bevægelse - hastighed

Strækning vs. tid for en bevægelse



Gennemsnitsfart i tidsintervallet Δt:

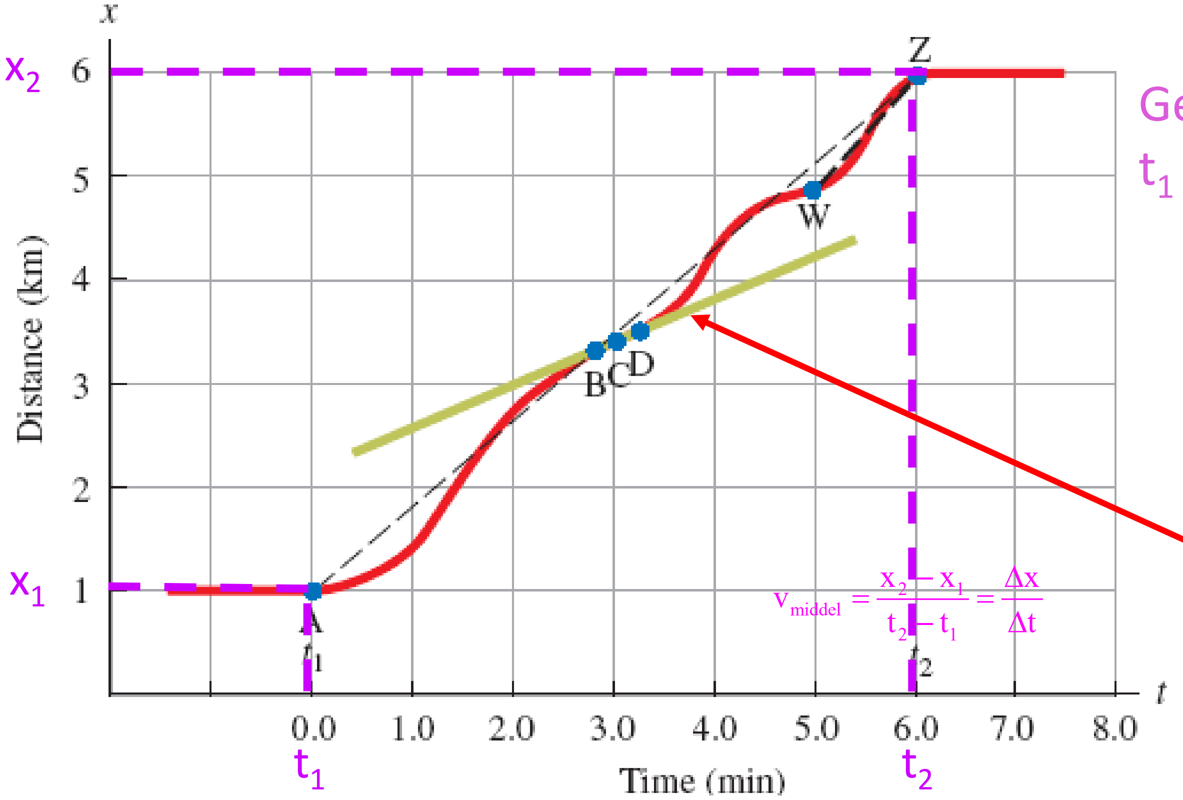
$$\boxed{v_{middel} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}} \quad (2\text{-}2)$$

Forskydning: $\Delta x \equiv x_2 - x_1$ (2-1)

Tidsinterval: $\Delta t = t_2 - t_1$

Lineær bevægelse - hastighed

Strækning vs. tid for en bevægelse



Gennemsnitsfart i tidsintervallet t_1 til t_2 (0 til 6s):

Hældning af tangenten i punktet C på x-t-kurven (t=3 s)

Øjeblikshastigheden til t=3 s:

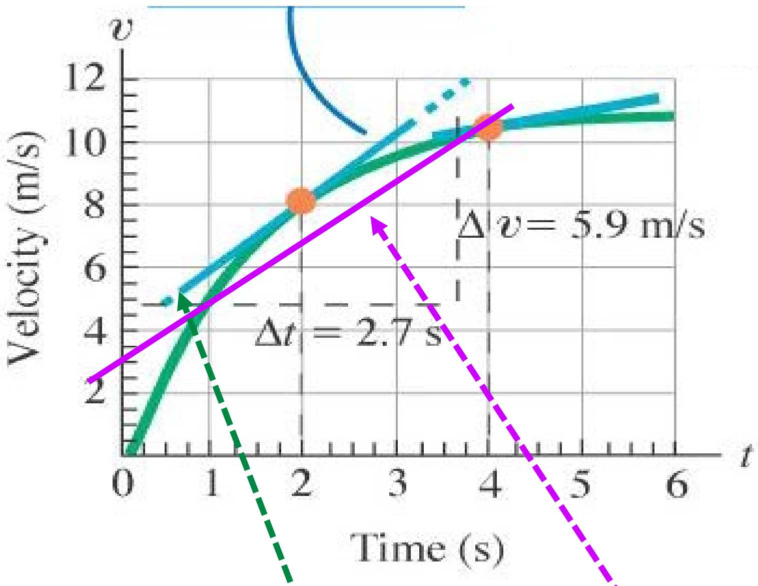
$$v(t) = \lim_{\Delta t \to 0} \frac{x(t + \Delta t) - x(t)}{\Delta t} = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

$$\boxed{v(t) = \frac{dx}{dt}}$$

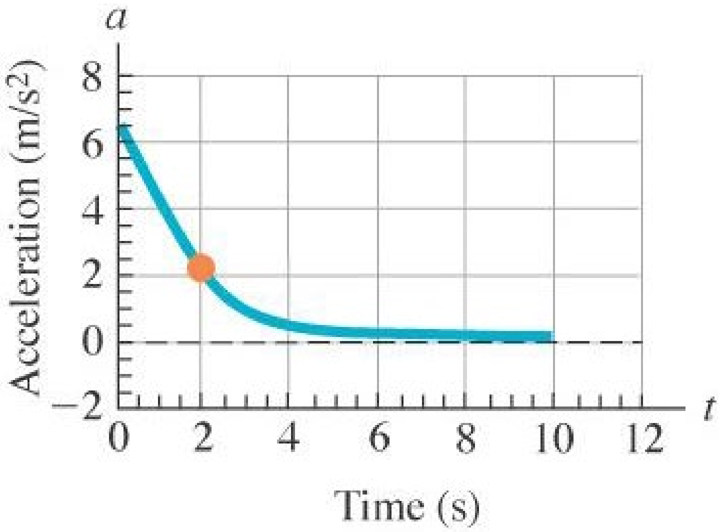
(2-4)

Lineær bevægelse - acceleration

Hastighed vs. tid



Acceleration vs. tid



(2-7)

Gennemsnits-acceleration:

$$a_{av} \equiv \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

Øjeblikkelig acceleration: (for t= 2s)

$$a \equiv \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt}$$

(2-8)

$$a = \frac{dv}{dt} = \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d^2x}{dt^2}$$

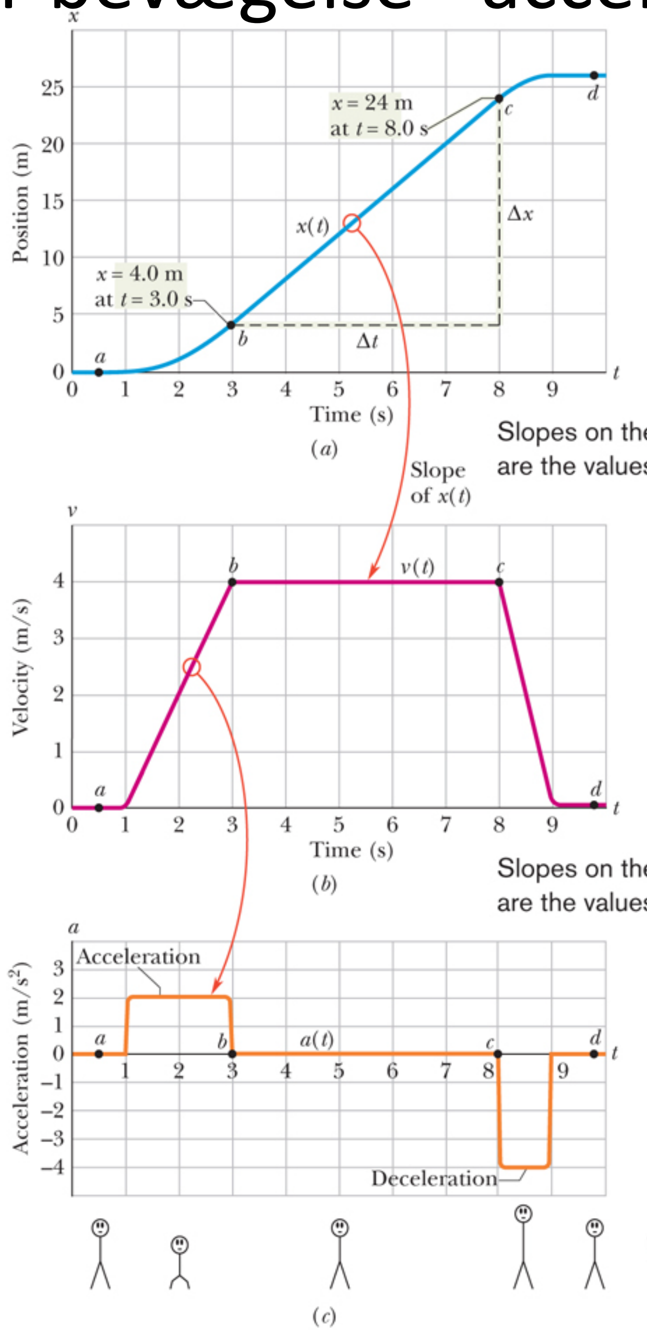
(2-9)

Lineær bevægelse - acceleration

$$x(t)$$

$$v(t) = \frac{dx}{dt}$$

$$a(t) = \frac{dv}{dt} = \frac{d^2x}{dt^2}$$



Sample problem 2.02

Elevator i opad bevægelse

Slopes on the x versus t graph are the values on the v versus t graph.

Slopes on the v versus t graph are the values on the a versus t graph.

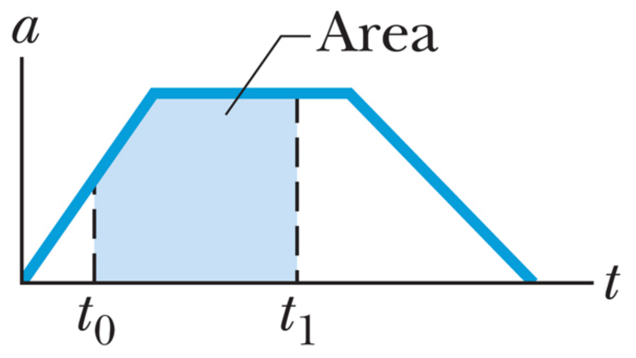
What you would feel.

Lineær bevægelse - acceleration

$$a(t) = \frac{dv}{dt} \Rightarrow dv = a(t)dt \quad \rightarrow$$

$$\int_{v_0}^{v} dv = \int_{t_0}^{t} a(t)dt \Rightarrow \boxed{\Delta v = v - v_0 = \int_{t_0}^{t} a(t)dt}$$

(2-27)

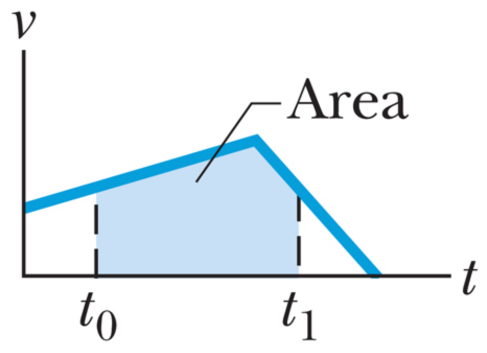


(a)

$$v(t) = \frac{dx}{dt} \Rightarrow dx = v(t)dt \rightarrow$$

$$\int_{x_0}^{x} dx = \int_{t_0}^{t} v(t)dt \Rightarrow \boxed{\Delta x = x - x_0 = \int_{t_0}^{t} v(t)dt}$$

(2-29)



(b)

Lineær bevægelse – <u>konstant</u> acceleration

Table 2-1 Equations for Motion with Constant Acceleration[a]

Equation Number	Equation	Missing Quantity
2-11	$v = v_0 + at$	$x - x_0$
2-15	$x - x_0 = v_0 t + \frac{1}{2}at^2$	v
2-16	$v^2 = v_0^2 + 2a(x - x_0)$	t
2-17	$x - x_0 = \frac{1}{2}(v_0 + v)t$	a
2-18	$x - x_0 = vt - \frac{1}{2}at^2$	v_0

[a]Make sure that the acceleration is indeed constant before using the equations in this table.

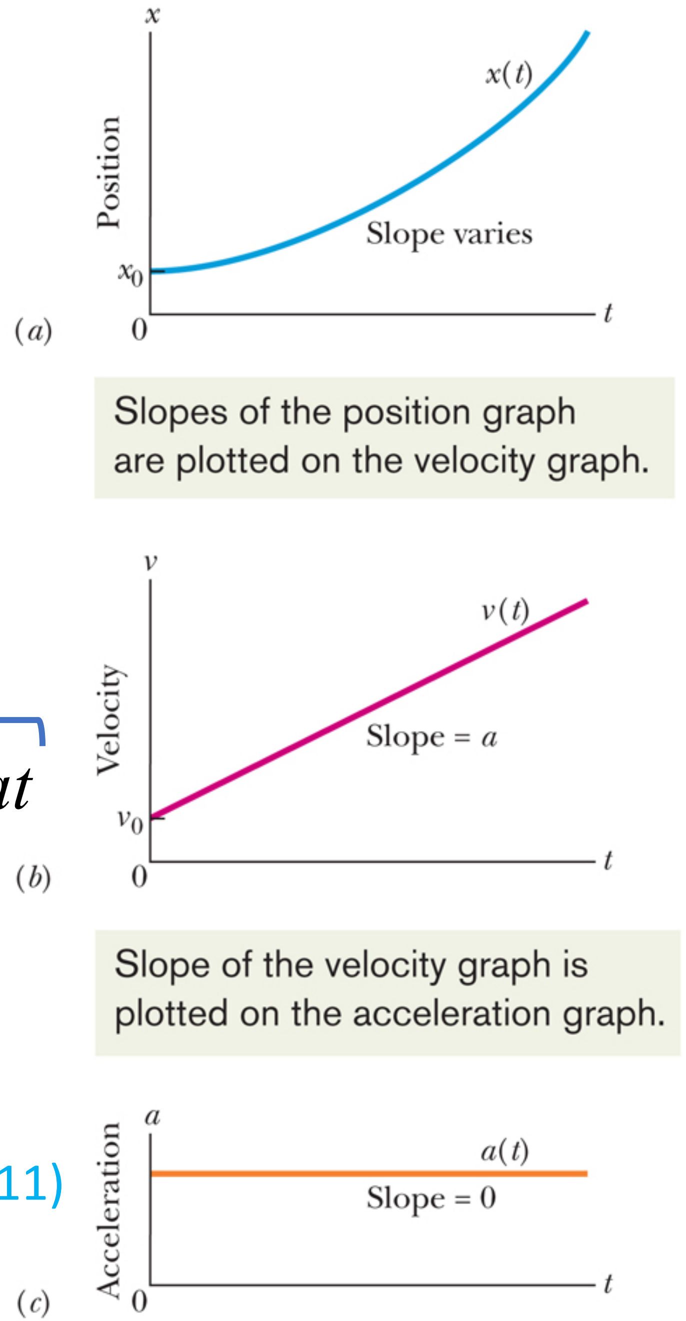
Lineær bevægelse – konstant acceleration

$$\boxed{x = x_0 + v_0 t + \frac{1}{2} a t^2} \qquad (2\text{-}15)$$

$$v_{avg} = \frac{x - x_0}{t - 0} \Rightarrow x = x_0 + v_{avg} t$$

$$v_{avg} = \frac{1}{2}(v_0 + v) = \frac{1}{2}(v_0 + v_0 + at) = \overbrace{v_0 + \frac{1}{2} at}$$

$$a = a_{avg} = \frac{v - v_0}{t - 0} \Rightarrow \boxed{\overbrace{v = v_0 + at}} \qquad (2\text{-}11)$$



Lineær bevægelse – konstant acceleration

(2-11) $$v = v_0 + at \Rightarrow t = \underbrace{\frac{v - v_0}{a}}$$

(2-15) $$x - x_0 = v_0 t + \frac{1}{2} a t^2 = v_0 \frac{v - v_0}{a} + \frac{1}{2} a \left[\frac{v - v_0}{a} \right]^2 \Leftrightarrow$$

$$2a(x - x_0) = 2 v_0 v - 2 v_0{}^2 + v^2 + v_0{}^2 - 2 v_0 v = v^2 - v_0{}^2 \Leftrightarrow$$

(2-16) $$\boxed{v^2 = v_0{}^2 + 2a(x - x_0)}$$

(2-11) $$v = v_0 + at \Rightarrow a = \underbrace{\frac{v - v_0}{t}}$$ eller $$v_0 = \underbrace{v - at}$$

(2-15) $$x - x_0 = v_0 t + \frac{1}{2} a t^2 = v_0 t + \frac{1}{2} \left[\frac{v - v_0}{t} \right] t^2 = \frac{1}{2} (v_0 + v) t$$

(2-18) $$x - x_0 = \frac{1}{2} [v - at + v] t = vt - \frac{1}{2} a t^2 \Rightarrow \boxed{x = x_0 + vt - \frac{1}{2} a t^2}$$

Bevægelse i 3 dimensioner - position

Position

$$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k} \qquad (4\text{-}1)$$

Forskydning

$$\Delta\vec{r} = \vec{r}_2 - \vec{r}_1 \qquad (4\text{-}2)$$

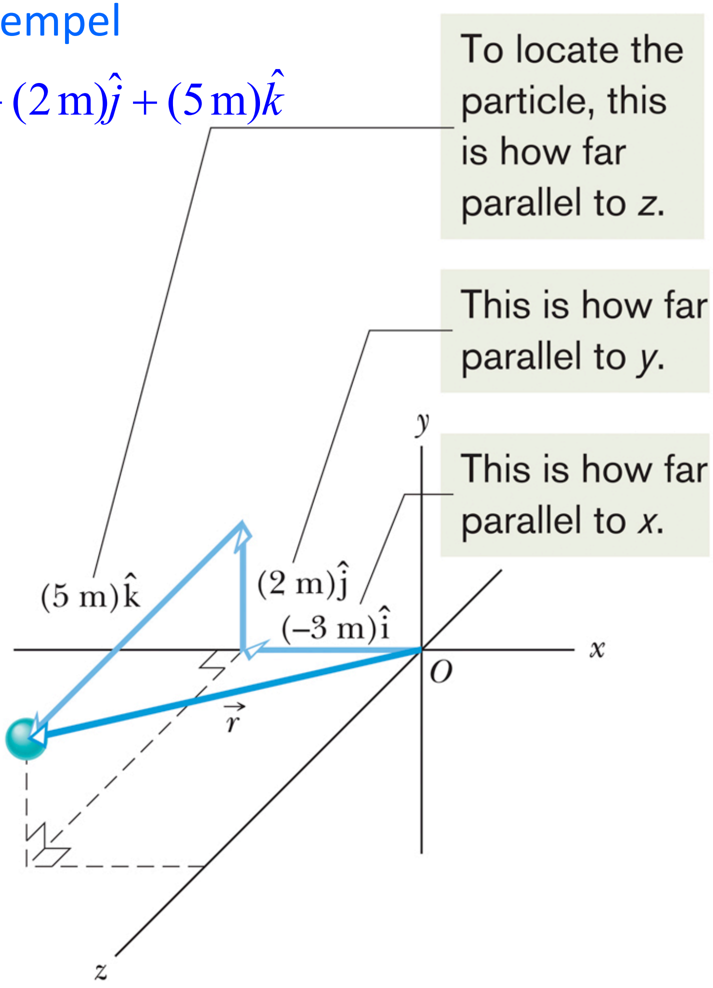
$$\Delta\vec{r} = x_2\hat{i} + y_2\hat{j} + z_2\hat{k} - (x_1\hat{i} + y_1\hat{j} + z_1\hat{k})$$

$$\Delta\vec{r} = (x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j} + (z_2 - z_1)\hat{k}$$

$$\Delta\vec{r} = \Delta x\hat{i} + \Delta y\hat{j} + \Delta z\hat{k} \qquad (4\text{-}4)$$

Eksempel

$$\vec{r} = (-3\,\text{m})\hat{i} + (2\,\text{m})\hat{j} + (5\,\text{m})\hat{k}$$

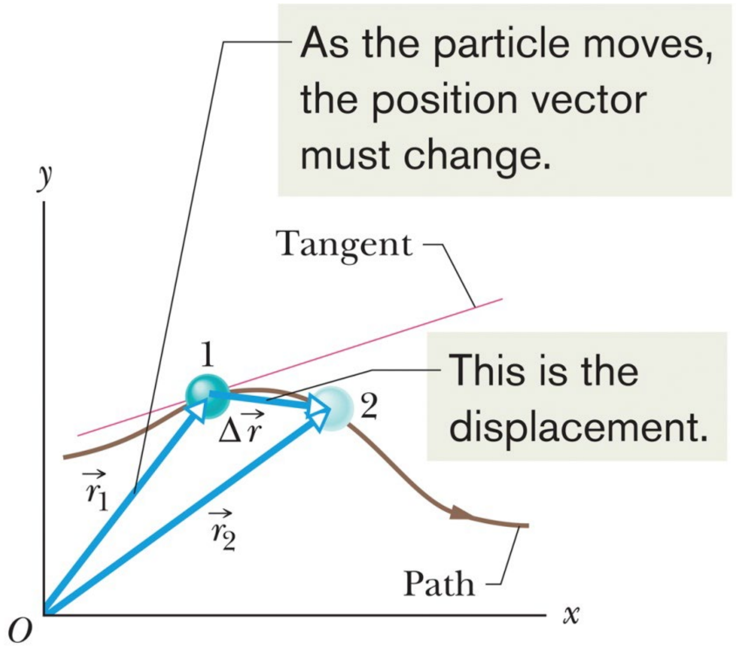


Bevægelse i 3 dimensioner - hastighed

Gennemsnitshastighed

$$\vec{v}_{avg} = \frac{\Delta \vec{r}}{\Delta t} \qquad (4\text{-}8)$$

$$\vec{v}_{avg} = \frac{\Delta x}{\Delta t}\hat{i} + \frac{\Delta y}{\Delta t}\hat{j} + \frac{\Delta z}{\Delta t}\hat{k} \qquad (4\text{-}9)$$

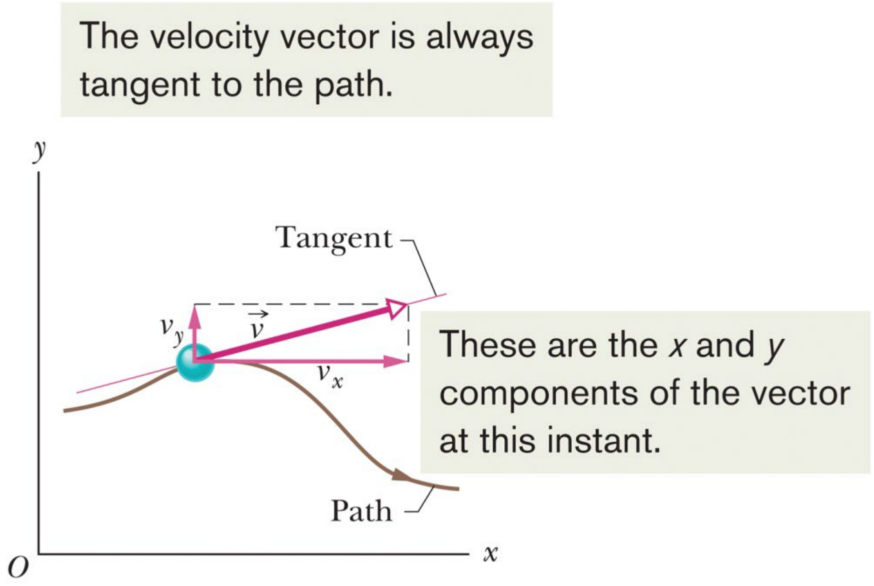


Øjebliksshastighed

$$\vec{v}(t) = \lim_{\Delta t \to 0} \frac{\vec{r}(t+\Delta t) - \vec{r}(t)}{\Delta t} = \frac{d\vec{r}}{dt}$$

$$\vec{v} = \frac{dx}{dt}\hat{i} + \frac{dy}{dt}\vec{j} + \frac{dz}{dt}\hat{k}$$

$$\vec{v} = v_x\hat{i} + v_y\vec{j} + v_z\hat{k} \qquad (4\text{-}11)$$



Bevægelse i 3 dimensioner - acceleration

Gennemsnitsacceleration

$$\vec{a}_{avg} = \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t} \qquad (4\text{-}15)$$

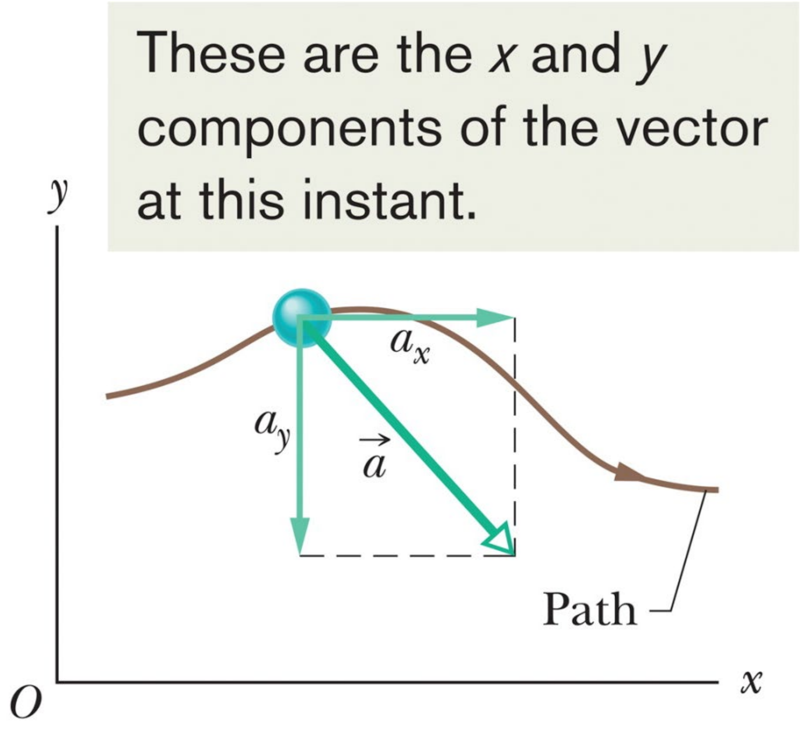
$$v_{avg} = \frac{\Delta x}{\Delta t}\hat{i} + \frac{\Delta y}{\Delta t}\hat{j} + \frac{\Delta z}{\Delta t}\hat{k}$$

Øjebliksacceleration

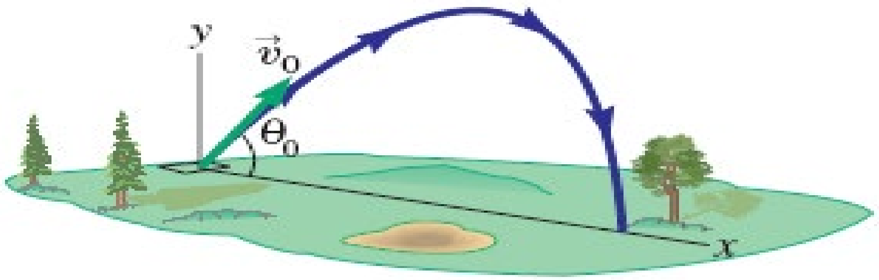
$$\vec{a}(t) = \lim_{\Delta t \to 0} \frac{\vec{v}(t+\Delta t) - \vec{v}(t)}{\Delta t} = \frac{d\vec{v}}{dt}$$

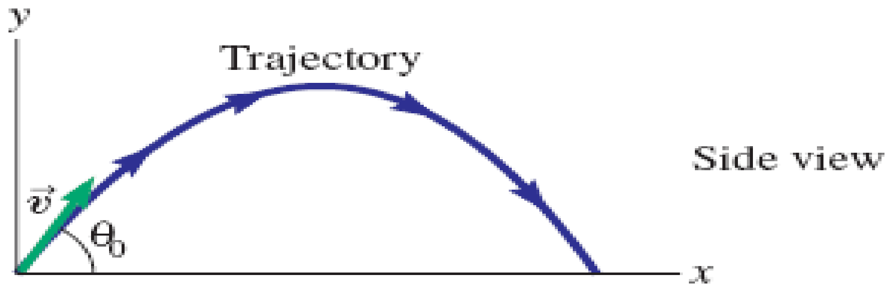
$$\vec{a} = \frac{dv_x}{dt}\hat{i} + \frac{dv_y}{dt}\vec{j} + \frac{dv_z}{dt}\hat{k} \qquad (4\text{-}18)$$

$$\vec{a} = a_x\hat{i} + a_y\vec{j} + a_z\hat{k}$$



Plan bevægelse - projektilbevægelsen





- Objekts bevægelse under indflydelse af tyngdekraften:

$$a_y = -g \qquad (g = 9.82\,\mathrm{m/s^2}\ \ (\mathrm{dk}))$$

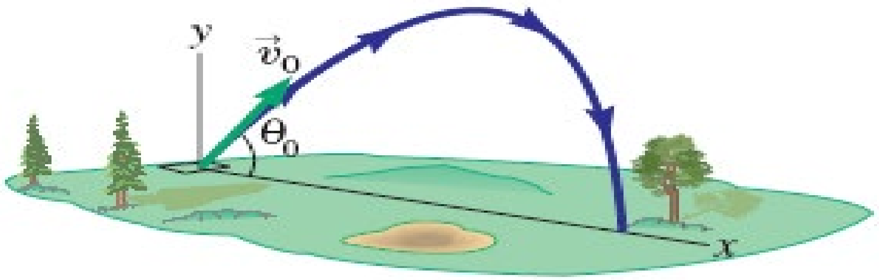
- Hastighedens x-komposant er konstant *(ikke påvirket af g):*

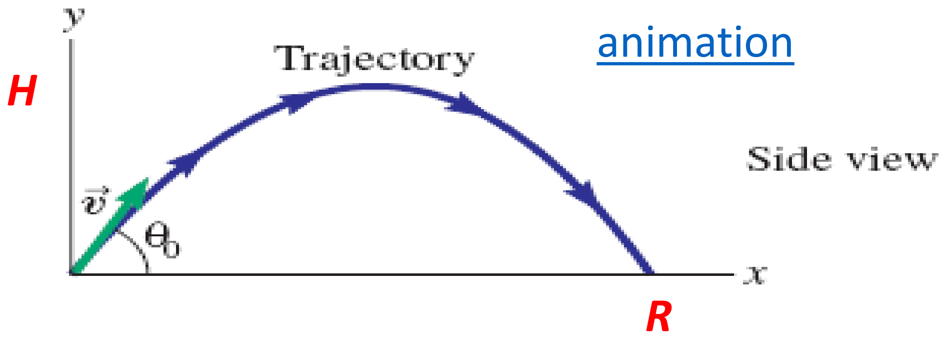
$$v_x = v_{0x} = v_0 \cos\theta_0 \ \Rightarrow \boxed{x = x_0 + (v_0 \cos\theta_0)t} \qquad \text{(4-21)}$$

- Hastighedens y-komposant findes ved at benytte ligninger for konstant acceleration:

$$v_y = v_{0y} - gt = v_0 \sin\theta_0 - gt \ \Rightarrow \boxed{y = y_0 + (v_0 \sin\theta_0)\mathrm{t} - \tfrac{1}{2}gt^2} \qquad \text{(4-22)}$$

Plan bevægelse - projektilbevægelsen





animation

Antager vi, at objektet kastes fra positionen $(x_0, y_0) = (0,0)$ fås:

$$x = (v_0 \cos\theta_0)t \Rightarrow t = \frac{x}{v_0 \cos\theta_0}$$

$$y = (v_0 \sin\theta_0)\,\mathrm{t} - \tfrac{1}{2} g t^2 = (v_0 \sin\theta_0)\left[\frac{x}{v_0 \cos\theta_0}\right] - \frac{1}{2} g \left[\frac{x}{v_0 \cos\theta_0}\right]^2 \Rightarrow$$

$$y = x \tan\theta_0 - \frac{1}{2}\left[\frac{g}{(v_0 \cos\theta_0)^2}\right] x^2$$ (4-25) (ligningen for en parabel)

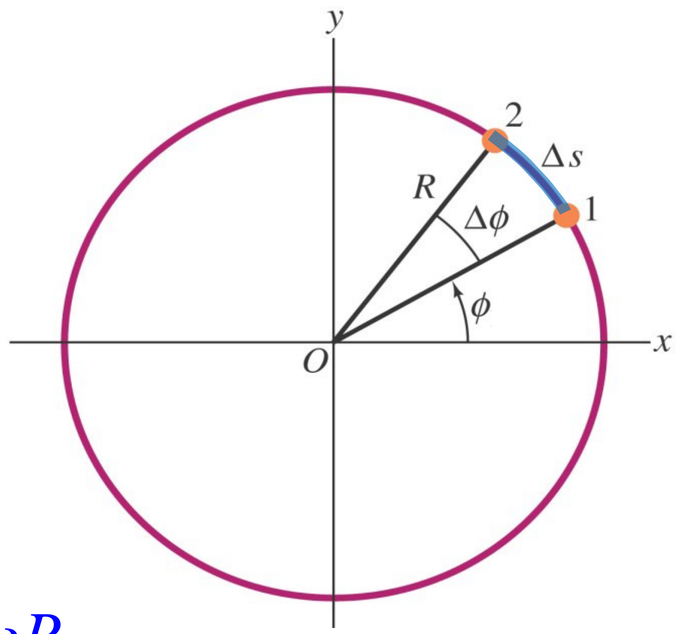
Kastelængde: $R = \frac{{v_0}^2}{g} \sin 2\theta_0$ Max højde: $H = \frac{{v_0}^2}{2g} (\sin\theta_0)^2$

Jævn cirkulær bevægelse

Beskrives ved polære koordinater:

Radius: *R*

Vinkel: *Φ*



Buelængde: $\Delta s = R\Delta\phi$

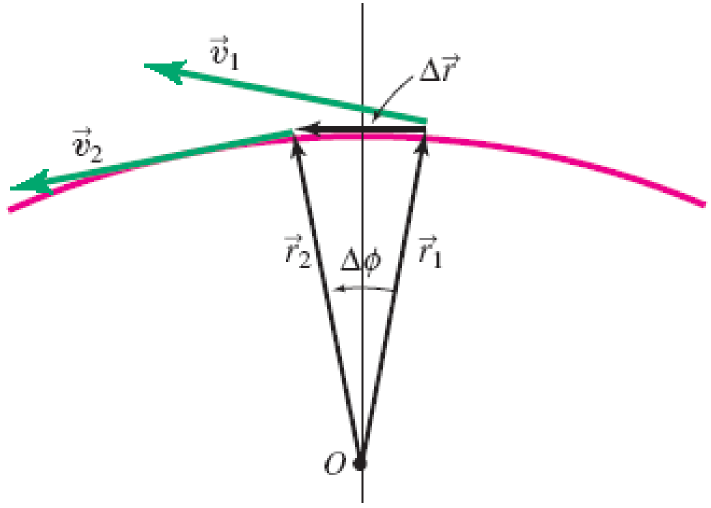
Øjeblikkelig hastighed: $v = \frac{ds}{dt} = R\frac{d\phi}{dt}$

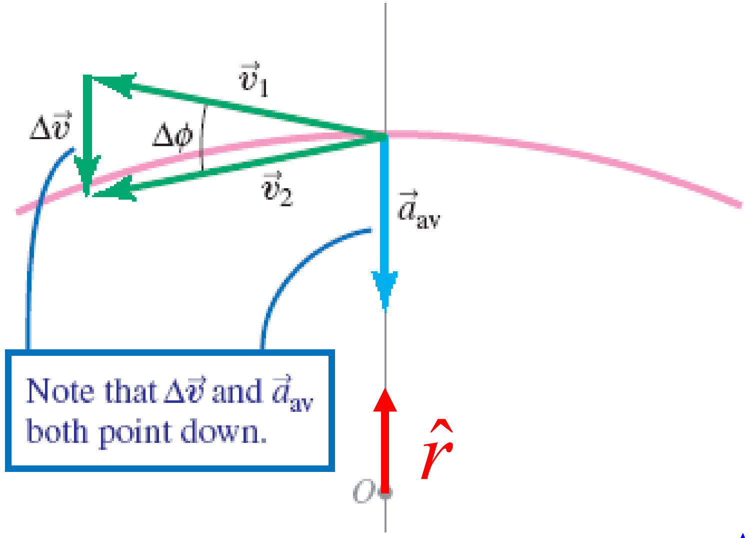
Vinkelhastighed: $\omega \equiv \frac{d\phi}{dt}$ $\quad v = \omega R$

Periodetid: $T = \frac{2\pi R}{v} = \frac{2\pi R}{\omega R} = \frac{2\pi}{\omega}$

Frekvens: $f = \frac{1}{T} = \frac{\omega}{2\pi}$ $\quad \omega = 2\pi f$

Jævn cirkulær bevægelse

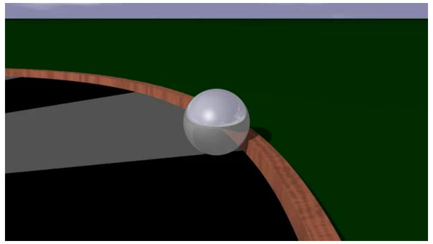




Ændringen i hastighedsvektoren angiver retningen af : $\vec{a}_{avg} = \frac{\Delta\vec{v}}{\Delta t}$

Ud fra de ligedannede trekanter i figurerne ses:

$$\frac{\Delta v}{v} = \frac{\Delta r}{r} \Leftrightarrow \Delta v = \frac{v}{r}\Delta r \Rightarrow \frac{\Delta v}{\Delta t} = \frac{v}{r}\frac{\Delta r}{\Delta t}$$



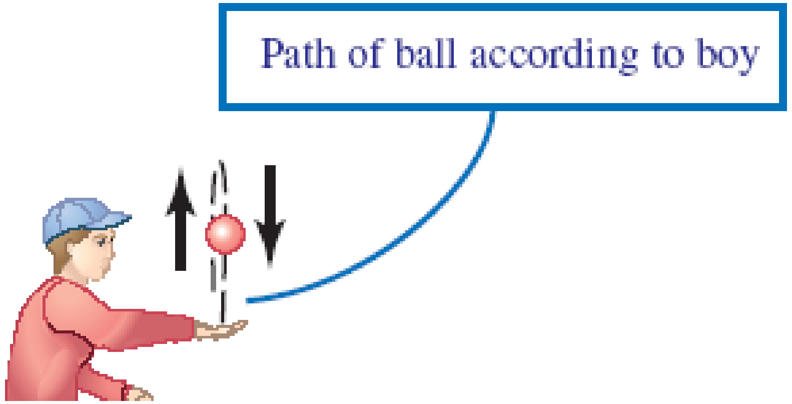
Den øjeblikkelige acceleration findes som:

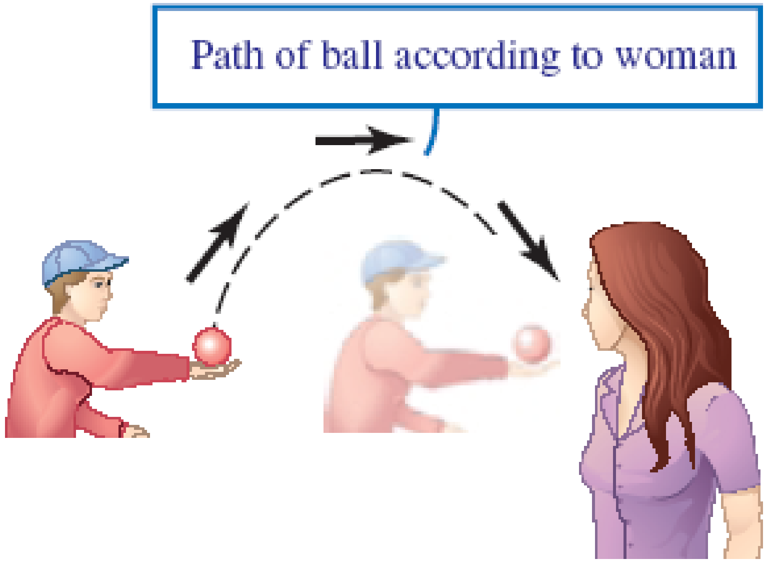
$$a = \lim_{\Delta t \to 0}\frac{\Delta v}{\Delta t} = \frac{v}{r}\lim_{\Delta t \to 0}\frac{\Delta r}{\Delta t} = \frac{v}{r}v = \frac{v^2}{r} = r\omega^2 \qquad (4\text{-}34)$$

$$\boxed{\vec{a} = -\frac{v^2}{r}\hat{r}}$$

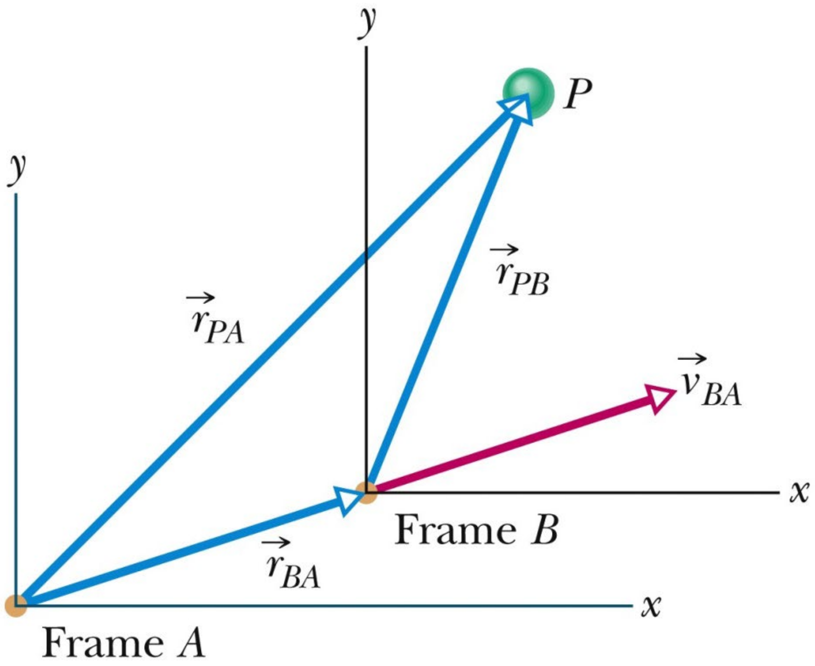
Relativ bevægelse

En dreng står stille en bus og kaster en bold op. Observatører som bevæger sig i forhold til hinanden vil beskrive bevægelsen forskelligt.





Relativ bevægelse



$$\vec{r}_{PB} = \vec{r}_{PB} + \vec{r}_{BA} \qquad (4\text{-}43)$$

$$\vec{v}_{PB} = \vec{v}_{PB} + \vec{v}_{BA} \qquad (4\text{-}44)$$

$$\vec{a}_{PA} = \vec{a}_{PB} \qquad (4\text{-}45)$$

Næste gang: Newton's Love

Newton's Første Lov

Et legeme som ikke er påvirket af en kraft, eller af kræfter der ophæver hinandens virkning, vil enten være i hvile eller foretage en jævn retlinet bevægelse.

Newton's Anden Lov

Et legeme med massen m, der påvirkes af en resulterende kraft F, vil have en acceleration a, som opfylder: $\vec{F} = m\vec{a}$

Newton's Tredie Lov

Et legeme A der påvirker et legeme B med en kraft, vil blive påvirket med en lige stor modsat rettet (Lov om aktion og reaktion)