PHY117 HS2023

Prof. Ben Kilminster

Sept. 19, 2023

Week 1, Lecture 1

Web page : https://www.physik.uzh.ch/de/lehre/PHY117/HS2023.html

PHY117, Physics for Life Sciences 1

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Schedule

Lecturer :	› Prof. Ben Kilminster
Lectures (PHY117.1):	**Tuesday 15:00 - 16:45**, Y04-G-30 (live broadcast to Y15-G-60) **Wednesday 15:00 - 16:45**, Y04-G-30 (live broadcast Y03-G-95)

Lectures and reference materials will be uploaded here

Course sheet (1): (on website)

PHY 117 HS 2023

Physics II for Biomed (Modern Physics)
Lecture : Tuesdays 13:00-15:00, Wednesdays 13:00-15:00 Y04-G-30

Professor Ben Kilminster (Email ben.kilminster@physik.uzh.ch)
Prof. K's office hours : 36-J-50 Tuesdays 12:00-13:00 (or by appointment)
Class page: https://www.physik.uzh.ch/de/lehre/PHY117/HS2023.html (user: physik-phy117, pass: einstein5%)

Teachers assistants :
Frau Ruth Bründler (ruth.bruendler@physik.uzh.ch) (English/German speaking) (In charge of exercises & sessions)
Fanqiang Meng (fanqiang.meng@uzh.ch) (English/Chinese speaking) In-class TA

Exercise session groups :

	Organisation UE	Ruth Bründler	ruth.bruendler@physik.uzh.ch
1	**Übungen**	Alessio Tassone	atassone@student.ethz.ch
2		Eduardo Ploerer	eduardo.ploerer@cern.ch
3		Eslam Shokr	eslam.shokr@physik.uzh.ch
4		Florian Leitner	florian.leitner@uzh.ch
5		Gabriel Cuenod	gabriel.cuenod@uzh.ch
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8		Loris Keller	loris.keller@uzh.ch
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10		Patrick van Workum	patrickblakemillen.vanworkum@uzh.ch
11		Sara Engeli	sara.engeli@uzh.ch
12		Sarina Michael	Sarina.michael98@gmail.com
13		Sharath Rameshbabu	rash@empa.ch
14		Thomas Vollrath	thomas.vollrath@uzh.ch
15		Yannic Göldi	yannic.goeldi@uzh.ch

Course sheet (2):

References:
Kilminster Physics 1 & 2 scripts (available on the course web site)
Introductory university physics text book. I use the following :

Tipler (Very good explanations, main text I follow)
Halliday & Resnick
Young & Freedman

(But these are all very similar. Find any one that explains the physics well for you.)

Assessments : **Please register on OLAT:** https://lms.uzh.ch/ This is how we send you assignments
Please log in to see if you can access the course. If not, check your UZH email is registered properly.

1) You will be assigned to one exercise session: Thursday 8:00-10:00, 13:00-15:00, 15:00-17:00; Friday 8:00-10:00, 13:00-15:00; Monday 13:00-15:00, 15:00-17:00. First exercise session: Sept. 28th, 29th, Oct. 2nd.
2) Written exercises: New exercise sheet every week, assigned on Monday/Tuesday. First homework assigned Sept. $25^{th}/26^{th}$. You will not be graded on these. You should attempt to **solve the problems on your own** since this develops the neutral circuitry necessary to solve exercises.
3) TAs will show how to solve assigned weekly exercise sheets, answer questions, and go through additional exercises if time. TAs will keep an attendance list. **Note: You really have to go to the exercise sessions.** This is where you learn how to solve problems. In your exams, you will have to solve very similar problems. One problem will be the same. Remember, you will need to practice solving exercises **yourself.**
4) **Final exam. (Jan. 17th).** UZH exam schedule
    a. Exam style :
        1. **Similar style to written exercises, but different.** (Memorizing solutions doesn't help)
        2. Will be in German and English
        3. Expect question from exercise sessions & relating to experiments shown in lecture
        4. Formula sheet will be provided. (No private information allowed.)
5) Grade : 100% final exam

Make sure you are registered for OLAT at lms.uzh.ch

23HS PHY117.1 Physik f...

- Lecture Recording
- Exercise sheets
- Forum exercises
- Forum general

23HS PHY117.1 Physik für die Life Sciences

Campuskurs

Welcome to Physics for Life Sciences

Lectures

Y04-G-30 has 577 seats, but currently more students are enrolled. The lecture will be broadcast to other lecture halls, in case there are no seats available:

Tuesday at 15:00 in lecture hall **Y04-G-30** (live broadcast to lecture hall **Y15-G-60**)
Wednday at 15:00 in lecture hall **Y04-G-30** (live broadcast to lecture hall **Y03-G-95**)

A podcast for the lecture will be recorded and will be available here in OLAT about 24 hours after the lecture.
Please understand that we only have limited influence on the processing time of the videos.

Even though we provide a podcast, we recommend attending the lecture on site as it is basically designed for that.

Exercise classes

Exercise class lists with information to room numbers and TAs (teaching assistants) will be published after the deadline for registration, no later than Monday 25.9.23.

If you want to change the group, please try to do so in the booking system as long as the registration is open.
*Requests to change to an other group will only be processed **after the deadline** and if there are good reasons we will try to make it possible.*

Prof. K and the PHY117 Team

Exercise sheets

FAQ

For all questions not directly related to the lecture PHY 117 (e.g. Questions about booking chemistry, mathematics or biology modules):
-> Studienberatung from biologists/biomedical scientists or the relevant subject

For other questions related to the booking of PHY 117 (e.g. late booking), exercise group assignments:
-> Frau Bründler (ruth.bruendler@physik.uzh.ch)

For questions about the content of the exercises:
-> Ruth Bründler (ruth.bruendler@physik.uzh.ch)

For questions about how to solve exercises:
-> Contact the TA of your assigned exercise group

For questions about the transfer of credits from previous physics lectures (e.g. PHY 118 or lectures at ETH):
-> Christof Aegerter (aegerter@physik.uzh.ch)

Reference materials

Physics I:

Introduction to physics

PHYSIK INSTITUT
UNIVERSITÄT ZÜRICH

PROF. BEN KILMINSTER

INTRODUCTION TO MECHANICS, WAVES, AND FLUID DYNAMICS

This script is the first part of an undergraduate course in introductory physics. It is typically taught in the first semester, with part 2 often taught in the second semester. The level of material is appropriate for physics majors as well as those in the life sciences. The latter may not be expected to learn the full level of detail included that would be expected of physics majors, but may still benefit from the additional material in order to understand better. It is recommended that students should be already familiar with geometry and also take or have taken a class in mathematics that covers vectors and calculus (derivatives and integrals).

Contents

Reference materials

Physics II:
Introduction to physics

PHYSIK INSTITUT
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PROF. BEN KILMINSTER

INTRODUCTION TO ELECTRICITY, MAGNETISM, ELECTROMAGNETISM, AND THERMODYNAMICS

This script is the second part of an undergraduate course in introductory physics. It is typically taught in the second semester, with part 1 often taught in the previous semester. The level of material is appropriate for physics majors as well as those in the life sciences. The latter may not be expected to learn the full level of detail that would be expected of physics majors, but may still benefit from the additional material in order to understand some concepts in more depth. It is recommended that students should be already familiar with geometry and also take or have taken a class in mathematics that covers vectors and calculus (derivatives and integrals).

Reference materials

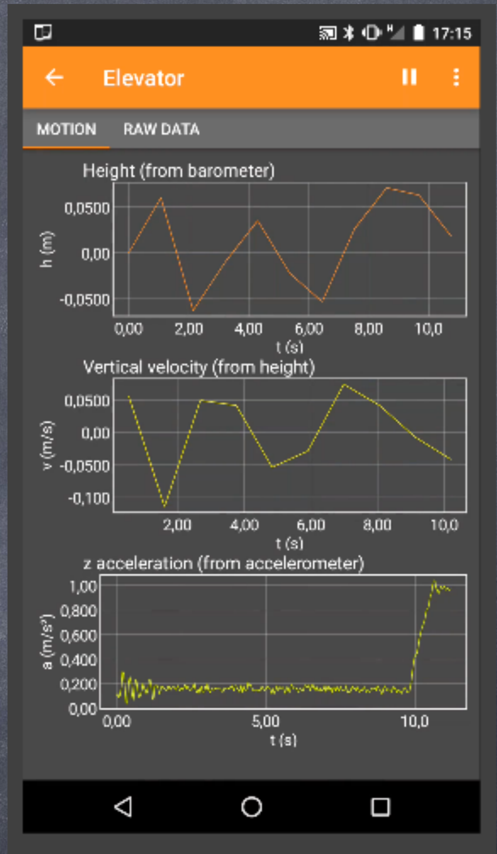
PHY 117 Physics Terms helper Prof. Ben Kilminster

physical quantity (SI base units in blue) (radiation physics units)	Deutsch	Symbol	SI unit	Simplified Formula to help with units	in other SI units	typical units in radiation physics	conversions
Length	Länge	ℓ	meter = m				
time	Zeit	t	second = s				
velocity	Geschwindigkeit	v	m/s			c=~3E8 m/s	
acceleration	Beschleunigung	a	m/s^2				
mass	Masse	m	kilogram = kg			$1eV/c^2$	$1eV/c^2$ = 1.78E-36 kg
momentum	Impuls	p	kg*m/s	p=mv			
force	Kraft	F	Newton = N	F = ma	$1N = kg*m/s^2$		
torque	Drehmoment	τ	N*m	$\tau = rF \sin\theta$	$kg*m^2/s^2$		
energy, work	Energie, Arbeit	E, W	Joule = J	W = Fx	$1J = kg*m^2/s^2$	1eV	1eV = 1.602E-19J
power	Leistung	P	Watt = W	P = E/t	$1W = kg*m^2/s$		
pressure	Druck	P	Pascal = Pa	P = F/area	$1Pa=1N/m^2$		
Electrical charge	Elektrische Ladung	q	Coulomb = C			e = electron charge	1e = 1.602E-19C

German-english helper

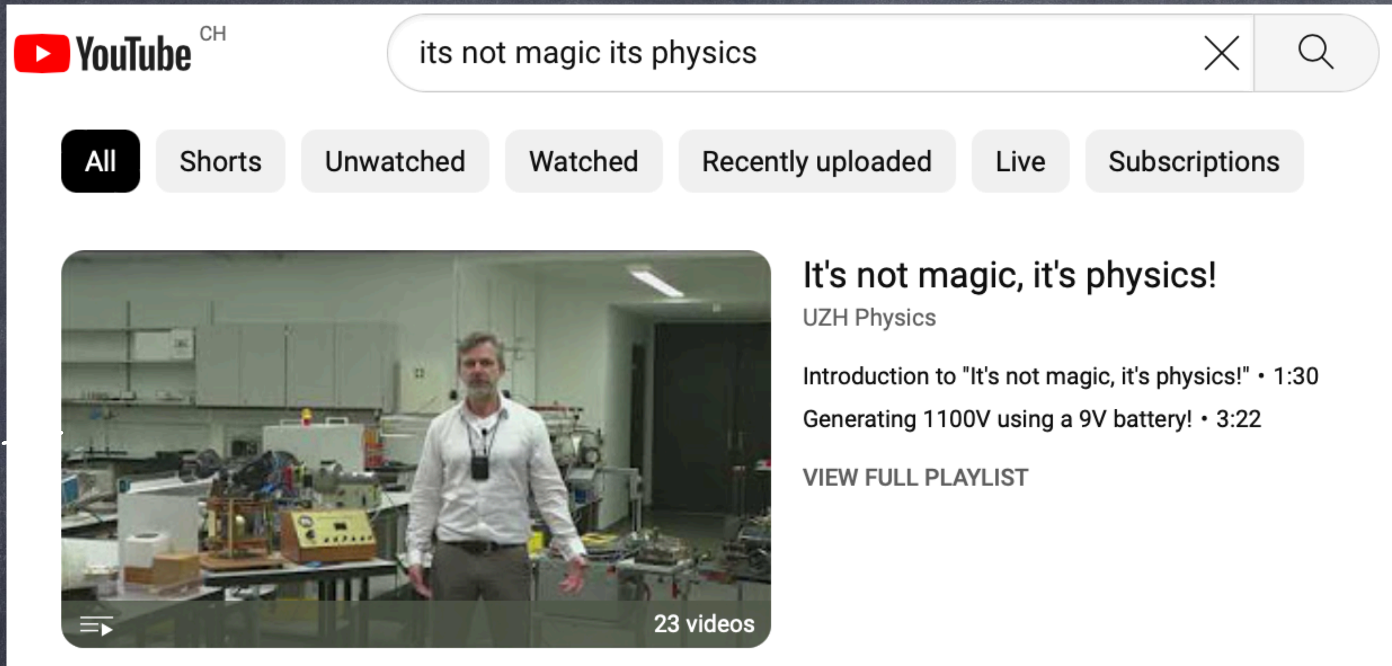
physical quantity (SI base units in blue) (radiation physics units)	Deutsch	Symbol	SI unit	Simplified Formula to help with units	in other SI units
Electrical current	Stromstärke	I	Ampere = Amp = A	I = q/t	1A=1C/s
Electric potential	Elektrische Spannung	V or ϕ	Volt = V	Power = IV	1V = 1W/A
Electric field	Elektrisches Feld	E	N/C = V/m		
Magnetic field	Magnetische Flussdichte	B	Tesla = T	$F=BI\ell$	1T=1N/(A*m)
Resistance	Elektrischer Widerstand	R	Ohms = Ω	V = IR	1Ω = 1V/A
Capacitance	Elektrische Kapazität	C	Farad = F	C=q/V	1F = 1C/V
Temperature	Temperatur	T	Kelvin = K		
amount of substance	Stoffmenge	N	Mol		
luminous intensity	Lichtstärke	I_v	Candela = cd		
radioactivity	Radioaktivität	A_{Bq}	Becquerel = Bq		1/s
Absorbed dose	Energiedosis	D_T	Gray = Gy		m^2/s^2 = J/kg
Equivalent dose	Åquivalentdosis	H_T	Sievert = Sv		m^2/s^2 = J/kg

Tools for exercises



Download for your smartphone:
(If your handy is not so handy, find a partner)

Youtube channel



https://youtu.be/tR4B0jQ0DPU?feature=shared

Physics

Deal with matter, energy, and the principles of motion for particles + waves.

- Interaction of particles
- Properties of:
  - small [molecules, atoms, nuclei, quarks
  - large [gases, liquids, solids

Physics explains the basics of chemistry, biology, geology, astronomy, cosmology, ...

PHY 117 is the foundation for PHY 127 (modern physics) will allow you to understand measurement tools like NMR, PET scans, CT scans, x-rays, synchrotrons, free electron lasers

some basic units

measurement	symbol	unit
distance	x	meter (m)
time	t	second (s)
mass	m	kilogram (kg)

From these units, we can derive other units

velocity	$V = \frac{x}{t}$	$\frac{m}{s}$
acceleration	$a = \frac{V}{t}$	$\frac{m}{s^2}$
force	$F = ma$	$\frac{kg \cdot m}{s^2} \rightarrow$ Newton (N)
energy	$E = F \cdot x$	$\frac{kg \cdot m^2}{s^2} \rightarrow$ Joule (J)

Dimensional analysis of units is a powerful tool

Is this a valid formula:

$$X = \frac{E}{F} + vt + \frac{a}{V}$$

Do the units work?

$$[m] \overset{?}{=} \left[\frac{\frac{kg\,m^2}{s^2}}{\frac{kg\,m}{s^2}}\right] + \left[\frac{m}{s}\cdot s\right] + \left[\frac{\frac{m}{s^2}}{\frac{m}{s}}\right]$$

$$[m] \neq [m] + [m] + \left[\frac{1}{s}\right]$$

NO

How many meters does light travel in one year?

$$c = 3.00 E 8 \frac{m}{s}$$

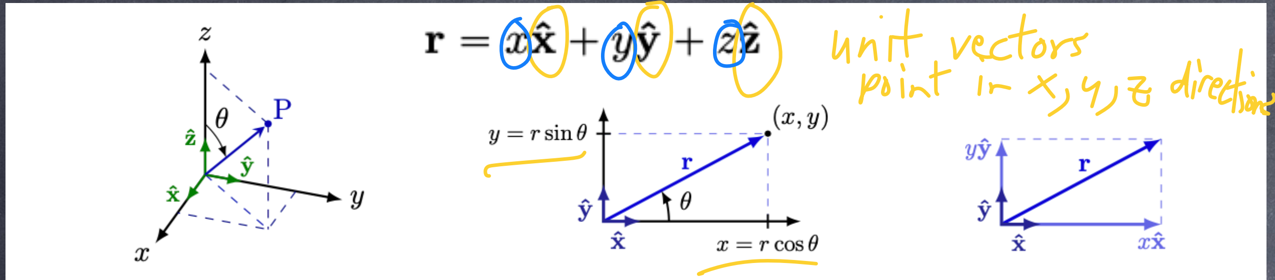
3 significant figures

$$X = vt = ct = \left(3.00 E 8 \frac{m}{s}\right)(1\ year)\left(\frac{365\ days}{1\ year}\right)\left(\frac{24\ hours}{1\ day}\right)\left(\frac{60\ minutes}{1\ hour}\right)\left(\frac{60\ seconds}{1\ minute}\right)$$

$$X = 9.46 E 15\ m$$

3 significant figures

Vectors are useful for describing a quantity with a magnitude & direction. (distance, velocity, acceleration, force ...)



(a) Position vector in a 3D Cartesian coordinate system.

(b) Position vector in a 2D Cartesian coordinate system.

(c) A vector can be broken down into its x and y vector components.

A vector has components that are perpendicular.

we use $\mathbf{a}$ or $\bar{r}$ or $\vec{r}$ as symbols for a vector.

The magnitude or length of a vector in 3-D is:

$$|\bar{r}| = \sqrt{x^2 + y^2 + z^2}$$

Example: $\bar{a} = 3\hat{x} + 2\hat{y} - 4\hat{z}$ $\quad |\bar{a}| = \sqrt{3^2 + 2^2 + (-4)^2} = \sqrt{29}$

$$|\hat{x}| = |\hat{y}| = |\hat{z}| = 1$$

In the script, you will find rules for vector operations: (also taught in MAT 182)

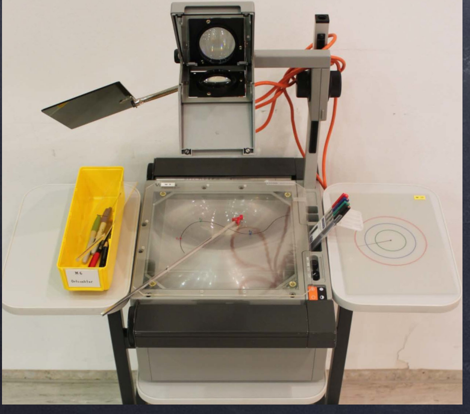
- adding vectors
- dot product $\bar{a} \cdot \bar{b}$

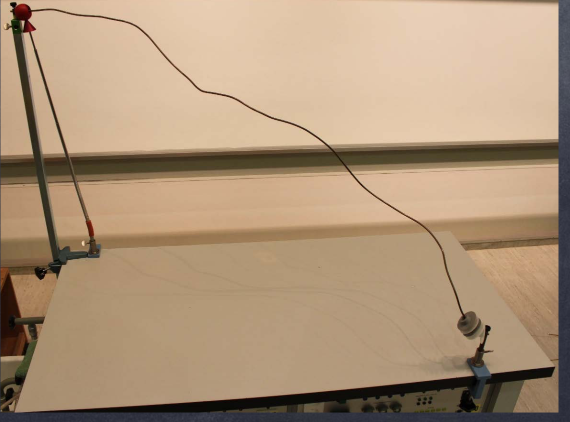
Motion is described by formulas (or functions) of time:

$$\left.\begin{aligned} x &= x(t) \\ y &= y(t) \\ z &= z(t) \end{aligned}\right\}$$ means that the formula depends on time.

Each component can be treated separately although time is the same in each formula.

The motion in 3 dimensions is described by a vector $\bar{r}(t) = x(t)\hat{x} + y(t)\hat{y} + z(t)\hat{z}$





Motion in 1 dimension: constant velocity

(a) Starting at $x(0) = 0$ at $t = 0$.

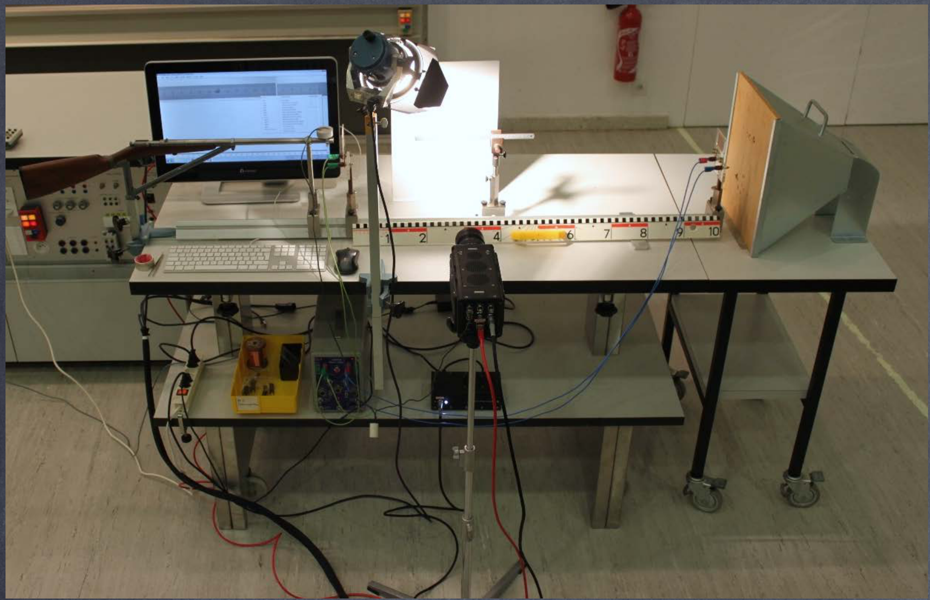
(b) Starting at an offset $x(0) = x_0$ at $t = 0$

velocity is the slope of x vs. t:

$$V = V_0 = \frac{x_2 - x_1}{t_2 - t_1}$$

$$\boxed{x(t) = x_0 + V_0 t}$$

constant velocity, 1 direction



$$\Delta x = \begin{array}{l} 1.1 \text{ cm} \\ 1.2 \text{ cm} \\ 1.1 \text{ cm} \end{array}$$

$$\Delta t = 4e{-5}\ s$$

25,000 frames/second

$$\langle \Delta x \rangle = \frac{\sum_{i=1}^{n} (\Delta x_i)}{n}$$

average Δx $= \langle \Delta x \rangle = \dfrac{(1.1+1.2+1.1) \text{ cm}}{3} = 1.13 \text{ cm}$

standard deviation Δx $= \sigma_{\Delta x} = \sqrt{\dfrac{\sum_{i}^{n} (\langle \Delta x \rangle - x_i)^2}{n-1}} = \sqrt{\dfrac{(0.03)^2 + (-0.07)^2 + (0.03)^2}{2}}$

$$\sigma_{\Delta x} = 0.06 \text{ cm}$$

measured

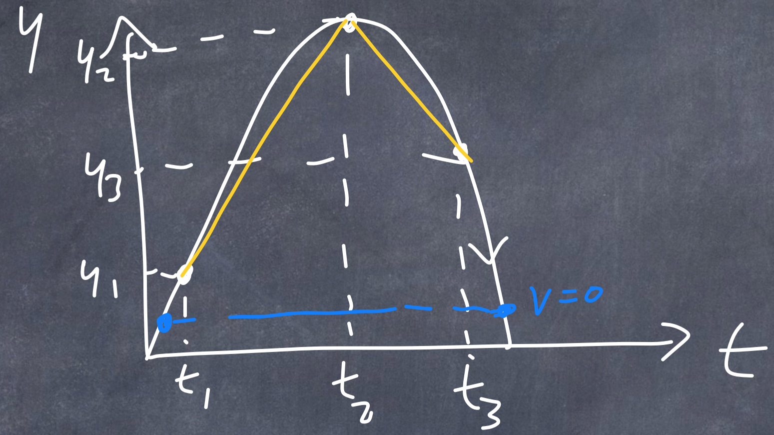
$\Delta x = 1.13 \pm 0.06$ cm

$$\text{speed} = |\bar{V}| = \frac{\Delta x}{\Delta t} = \frac{1.13\ \text{cm}}{4\text{E}-5\ \text{s}} = \frac{1.13\text{E}-2\ \text{m}}{4\text{E}-5\ \text{s}}$$

$$\boxed{\text{speed} = 283\ \frac{\text{m}}{\text{s}}}$$

speed of sound: $343\ \frac{\text{m}}{\text{s}}$

what if velocity changes?



↑ +y

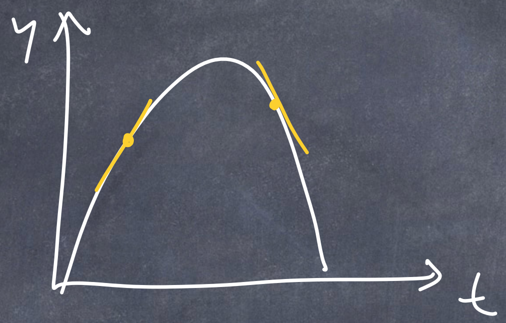
(example: ball thrown vertically)

we can calculate an average velocity between any 2 points:

$t_1 \to t_2$: $V = \dfrac{y_2 - y_1}{t_2 - t_1}$ + slope

$t_2 \to t_3$: $V = \dfrac{y_3 - y_2}{t_3 - t_2}$ − slope

As time Δt gets smaller, we approach the instantaneous velocity at each moment in time.



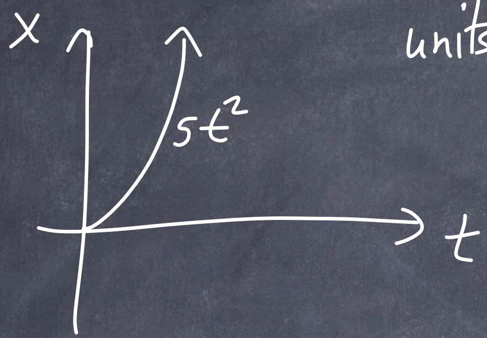
The tangent of the curve of distance vs. time is the instantaneous velocity.

As $\Delta t \to 0$ (Δt approaches 0)

$$V = \lim_{\Delta t \to 0} \frac{\Delta y}{\Delta t} = \frac{dy}{dt}$$ = slope of the line tangent to the y vs. t curve

magnitude of $\frac{dy}{dt}$ is $\left|\frac{dy}{dt}\right|$ = speed

If $x(t) = 5t^2 \left[\frac{m}{s^2}\right]$, what is $v(t)$?



units $x(t) = \left(5\,\frac{m}{s^2}\right) t^2$ check: x has units of [m]

Let's calculate $v(t)$ the "old-fashioned" way

At a later time $t + \Delta t$, the position is

$$x(t+\Delta t) = 5(t+\Delta t)^2 = 5t^2 + 10t\Delta t + 5(\Delta t)^2$$

The change $\Delta x = x(t+\Delta t) - x(t)$

$$\Delta x = \cancel{5t^2} + 10t\Delta t + 5(\Delta t)^2 - \cancel{5t^2}$$

$$\Delta x = 10t\Delta t + 5(\Delta t)^2$$

$$\text{average velocity} = \frac{\Delta x}{\Delta t} = \frac{10t\cancel{\Delta t} + 5(\Delta t)^2}{\cancel{\Delta t}} = \frac{\Delta x}{\Delta t} = 10t + 5(\Delta t)$$

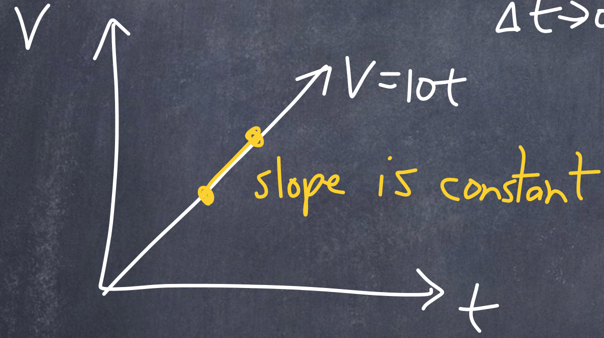
the instantanteous velocity $V = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = 10t + 5\Delta t$ (with $5\Delta t \to 0$)

$$V = 10t$$

what about the acceleration?

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

this is the line tangent to the V vs. t curve



Repeating, we find $\Delta V = V(t+\Delta t) - V(t)$

$$= 10(t+\Delta t) - 10t$$

$$= 10t + 10\Delta t - 10t$$

$$a = \frac{\Delta V}{\Delta t} = \frac{10\Delta t}{\Delta t} = 10$$

$a = \frac{dv}{dt}$ $\qquad$ $v = \frac{dx}{dt}$

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

acceleration is the second derivative of the position "with respect to" (wrt) time

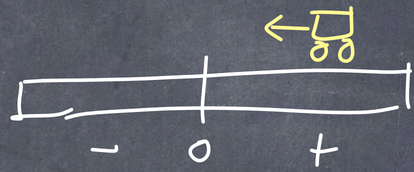
MAT. 182

General rules for derivatives:

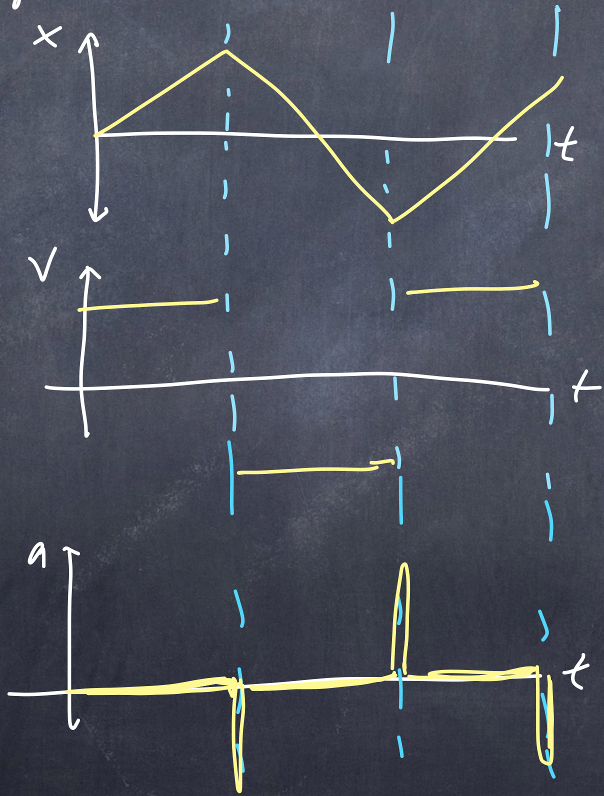
If $x = c\,t^n$ ← number

↑ constant

then $\frac{dx}{dt} = Cnt^{n-1}$



Air car experiment



velocity is slope of x vs.t.

acceleration is slope of v vs. t

Experiments