PHY117 HS2026

Find the lecture notes for today here:

https://www.physik.uzh.ch/de/lehre/PHY117/HS2026.html

user: physik-phy117, pass: einstein5%

Prof. Ben Kilminster

Prof. Florencia Canelli

Sept. 15th, 2026

Week 1, Lecture 1

Lectures also streamed to 15-G-60
(if you can't get a seat here)

Uhrzeit	Raum
15:00 - 17:00	Y04-G-30 Y15-G-60

Web page : https://www.physik.uzh.ch/de/lehre/PHY117/HS2026.html

Lectures and reference materials will be uploaded here

PHY117, Physics for Life Sciences 1

- ↓ Schedule
- ↓ Lecturer
- ↓ Course information sheet
- ↓ References & texts
- ↓ Exercises & Online quizzes
- ↓ Exam schedule
- ↓ Grades
- ↓ Outline of course
- ↓ Lecture information

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 Y15-G-60) Webcasts will be available on OLAT. (Unfortunately, the smell of gunpowder is not rendered.)

Lectures with and without notes

Lecture schedule (13 lectures)	**Topics**	Lecture notes	Additional resources
Week 1 Sept. 15-16, 2026	**Intro, units, principles of motion**	↓ PHY117_HS2026_Week1_L1.pdf (PDF, 14 MB) ↓ PHY117_HS2026_Week1_L1.prenotes.pdf (PDF, 12 MB)	Physics 1 script: chapters 1-5

Course info sheet (1): (on website)

PHY117-info-sheet-2026.pdf

PHY 117 HS 2026

Physics II for Biomed (Modern Physics)
Lectures: Tuesdays 13:00-15:00, Wednesdays 13:00-15:00 **Y04-G-30** (overflow: Y15-G-60)

Prof. Ben Kilminster (ben.kilminster@physik.uzh.ch), Prof. Florencia Canelli (florencia.canelli@physik.uzh.ch)
Prof. K's office hours : 36-J-50 Tuesdays 12:00-13:00 (or by appointment – please arrange in the breaks)
Class page: https://www.physik.uzh.ch/de/lehre/PHY117/HS2026.html (user: physik-phy117, pass: einstein5%)

Teachers assistants :
Frau Ruth Bründler (ruth.bruendler@physik.uzh.ch) (English/German speaking): In charge of exercises & sessions
Anson Kwok (English/Mandarin/Cantonese speaking): In-class TA

Exercise session groups :

1	**Classes**	Adrian Omlin
2		Archimedes Wildhaber
3		Bryan Koch
4		Céline Wallart
5		Danel Scheiner
6		David Annoni
7		Esteban Tapia Peñas
8		Ethan Sebastian
9		Hugo Schreckenberg
10		Julia Schmied
11		Kilian Schönenberger
12		Lukas Blose
13		Marc Urech
14		Maurice Matthäus
15		Ryan Samolis
16		Shaip Gashi

Info sheet (2):

References:
Kilminster's Physics 1 & 2 scripts (available on the course web site)
Introductory university physics text book. We use the following :
Tipler (Very good explanations, main text I follow)
Halliday & Resnick (similar)
Young & Freedman (similar)
(Find 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) Weekly OLAT quizzes: These are conceptual questions (true/false). You can complete these on OLAT to test your understanding of the lecture. 17% of the final exam will be in a similar format to these questions.
2) Weekly written exercises: 83% of the final exam will be similar to these questions.
   a. New exercise sheet every week, assigned on Monday. First homework published this week. You will not be graded on these. You should try to **solve the problems on your own** since this develops the neutral circuitry necessary to solve exercises. (To pass final exam!!)
   b. You will be assigned to one exercise session: Monday 13:00-15:00, 15:00-17:00, Thursday 8:00-10:00, 13:00-15:00, 15:00-17:00; Friday 8:00-10:00, 13:00-15:00.
      First exercise sessions: Thu. Sept. 24th, Fri. Sept. 25th, Mon. Sept. 28th
   c. 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 should 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 almost be the same. Remember, you need to practice solving exercises yourself. Memorizing solutions will not help – what helps is learning how to solve problems like these.
3) **Final exam. (Jan. 20th, 2027).** **UZH exam schedule**
   a. Exam style :
      1. **Similar style to OLAT and written exercises, but different problems.** (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 (available online). (No private information allowed.)
      5. We also provide calculators.
4) Grade : 100% final exam

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

Weekly exercises & quizzes here

Discussion about the lecture here.

Discussion about the exercises here.

FAQ

Q: When do I get assigned to an exercise session?
A: Registration ends Sept. 18th, assignments will be published by Sep. 21st. First exercise session: Thursday, Sept. 24th.

Q: Can I change my exercise session ?
A: We will only consider requests to switch groups after the registration deadline has passed, and only in cases of scheduling conflicts; with so many students, there's no other way to handle it.

For 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:
-> Frau Bründler (ruth.bruendler@physik.uzh.ch)

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

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

Reference materials

Ben Kilminster, Introductory Physics 1. Physics-1-Kilminster-2026.v1 (PDF, 5 MB)

Ben Kilminster, Introductory Physics 2. Physics-2-Kilminster-2026.v1 (PDF, 4 MB)

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).

These notes provide a deeper understanding of the material. Some of it is beyond what is taught in lecture and beyond what you need to know.

Reference materials

Physics II:
Introduction to physics

PHYSIK INSTITUT
UNIVERSITÄT ZÜRICH

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: German-English helper

PHY 117 Physics Terms 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	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	τ = rF sinθ	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

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=BIℓ	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	Äquivalentdosis	H_T	Sievert = Sv		m^2/s^2 = J/kg

Formula sheet (same as final exam)

PHY117 Formula Sheet

Mechanics

Velocity	$\vec{v} = \frac{d\vec{r}}{dt}$
Speed	$v = \lvert\vec{v}\rvert$
Acceleration	$\vec{a} = \frac{d\vec{v}}{dt}$
Acceleration components	$a_r = \frac{v^2}{r}$ and $a_T = \frac{d\lvert\vec{v}\rvert}{dt}$
Position	$x(t) = x_0 + v_0 t + \frac{1}{2}at^2$
Velocity	$v^2 = v_0^2 + 2a\Delta x$ and $v(t) = v_0 + at$
Newton's second law	$\sum \vec{F} = m\,\vec{a}$
Newton's third law	$\vec{F}_{12} = -\vec{F}_{21}$
Gravitational force	$\vec{F}_g = m\vec{g}$
Gravitational force law	$\vec{F}_g = \frac{Gm_1m_2}{r^2}$
Newtons second law of rotation	$\sum \tau = I\alpha$
Centripetal force	$F_r = \frac{m\,v^2}{r} = mr\omega^2$
Centripetal acceleration	$a_r = \frac{-v^2}{r}\hat{r} = -r\omega^2\hat{r}$
Angular position	$\Delta s = r\Delta\theta$ and $\theta(t) = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$
Angular velocity	$\omega = \frac{d\vartheta}{dt} = \frac{v}{r}$ and $\omega = \frac{2\pi}{T}$ and $\omega = \omega_0 + \alpha t$
Angular acceleration	$\alpha = d\omega/dt$
Angular momentum	$\vec{L} = \vec{r} \times \vec{p}$ and $\vec{L} = I\vec{\omega}$
Coordinates center of mass	$r_{cm} = \frac{\sum_i^n m_i\, r_i}{\sum_i^n m_i}$
Torque	$\vec{\tau} = \vec{r} \times \vec{F}$ and $\vec{\tau} = \frac{d\vec{L}}{dt}$
Impulse	$\vec{F}\Delta t = \Delta\vec{p} = m\Delta\vec{v}$

Energy and work

Kinetic energy:	$K = \frac{1}{2}mv^2$
Potential energy (gravity)	$U = mgh$
Potential energy (spring)	$U = \frac{1}{2}kx^2$
Work	$W_{1\to2} = \int_1^2 \vec{F}d\vec{r}$ and $W_{1\to2} = \int_1^2 \tau d\theta$
Work-energy theorem	$W_{1\to2} = K_2 - K_1$ and $W = \Delta K = -\Delta U$
Work and potential energy	$\Delta U = -W$
Law of conservation of energy	$K + U =$ constant

Fluids

Hydrostatic

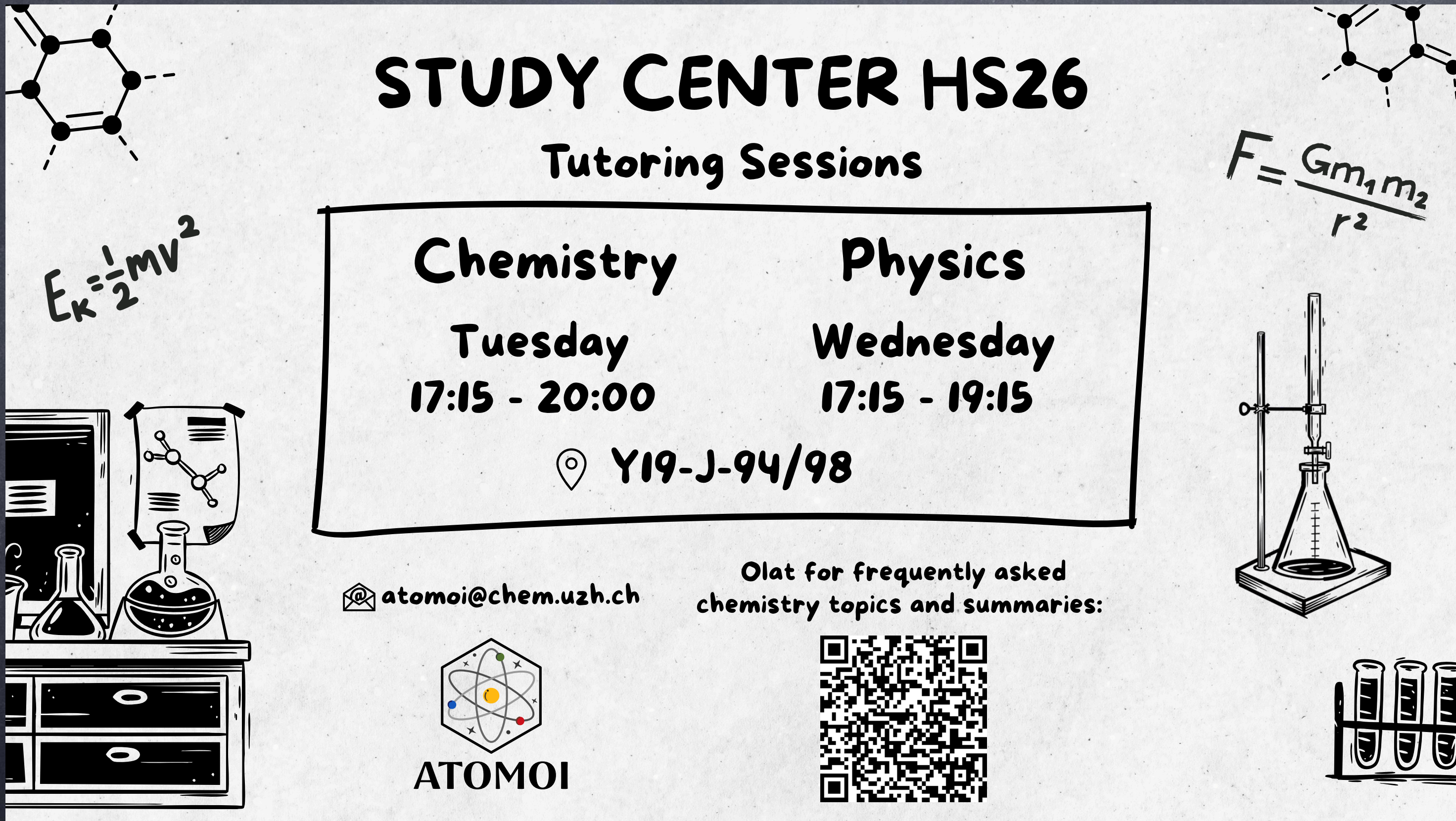
Pressure	$p = \frac{F}{A}$
Compressibility	$B = -\frac{p}{\frac{\Delta V}{V}}$
Pressure distribution in liquids	$p = p_0 + \rho gh$
Capillarity	$\Delta h = \frac{2\gamma\cos\theta_c}{\rho gr}$
Buoyancy	$F_b = \rho_{\mathrm{l}} V_{\mathrm{dis}} g$
Bouyancy in centrifuge	$F_b = m_l\omega^2 r$
Centrifugal "force"	$F_c = m_o\omega^2 r$

Hydrodynamics

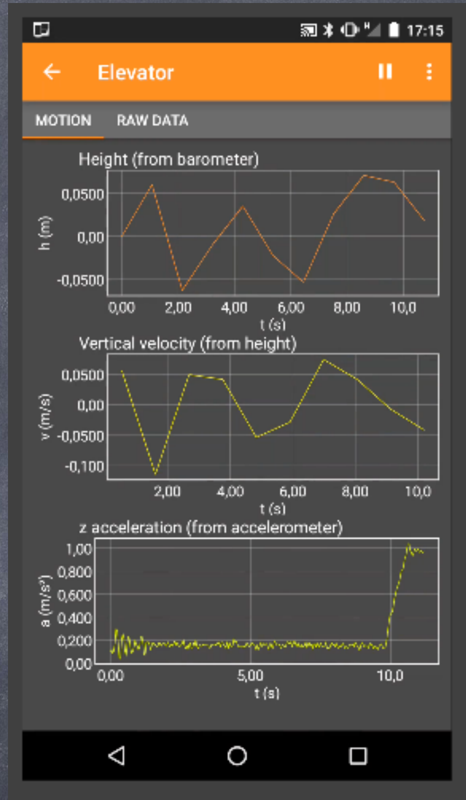
Flow rate	$I_V = \frac{\Delta V}{\Delta t} = Av$ v: homogeneous velocity

Practice for the exam by using this formula sheet as a starting point for solving weekly exercises

Physics help!

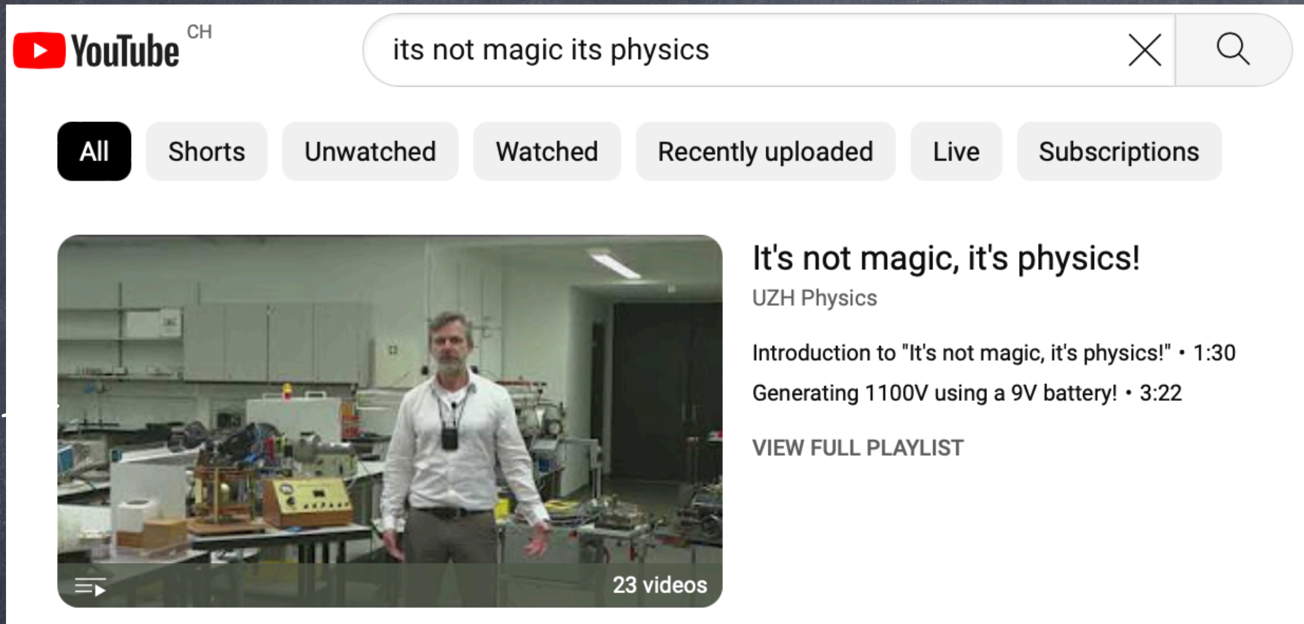


Tools for exercises



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

Youtube channel



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

Physics:

Deals with matter, energy, & the principles of motion for particles and waves

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

Physics explains chemistry, biology, geology, astronomy, cosmology, ...

PHY 117 also provides a foundation for PHY 127 (modern physics for biology/biomedicine) that 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 derive other units

velocity	$v = \frac{x}{t}$	$\frac{m}{s}$	
acceleration	$a = \frac{v}{t}$	$\frac{m}{s^2}$	
force	$F = ma$	$\frac{kg \cdot m}{s^2}$ $\longrightarrow$	Newton (N)
energy	$E = F \cdot x$	$\frac{kg \cdot m}{s^2} \cdot m$ $\longrightarrow$	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?

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

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

NO

How many meters does light travel in one year?

$$C = \underbrace{3.00}_{\text{3 significant figures}}E8\ \frac{m}{s}$$

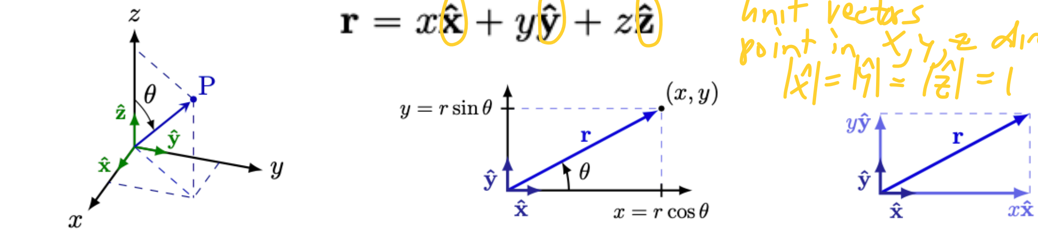
$$x = vt = ct = \left(3.00E8\ \frac{m}{s}\right)\left(1\ \cancel{year}\right)\left(\frac{365\ \cancel{days}}{1\ \cancel{year}}\right)\frac{24\ \cancel{hours}}{(1\ \cancel{day})}\ \frac{60\ \cancel{minutes}}{1\ \cancel{hour}}\cdot\frac{60\ s}{1\ \cancel{minute}}$$

$$x = \underbrace{9.46}_{\text{3 significant figures}}E15\ m$$

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

$$\mathbf{r} = x\hat{\mathbf{x}} + y\hat{\mathbf{y}} + z\hat{\mathbf{z}}$$

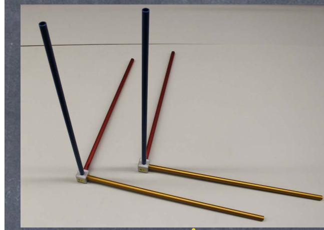
unit vectors point in x, y, z directions
$|\hat{x}| = |\hat{y}| = |\hat{z}| = 1$



(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.



you may have used: $\hat{i}, \hat{j}, \hat{k}$ or $\hat{e}_x, \hat{e}_y, \hat{e}_z$

A vector has components that are perpendicular.

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

The magnitude of a vector in 3-D is

$$|\bar{r}| = \sqrt{x^2 + y^2 + z^2} = r \quad \text{(scalar)}$$

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

In the script, you find rules for vector operations

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

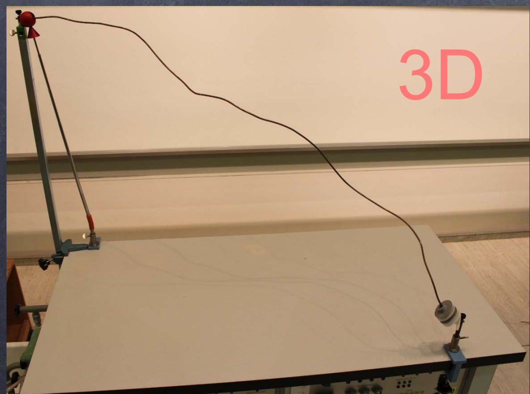
(also taught in MAT 182)

Motion is described by formulas or functions of time:

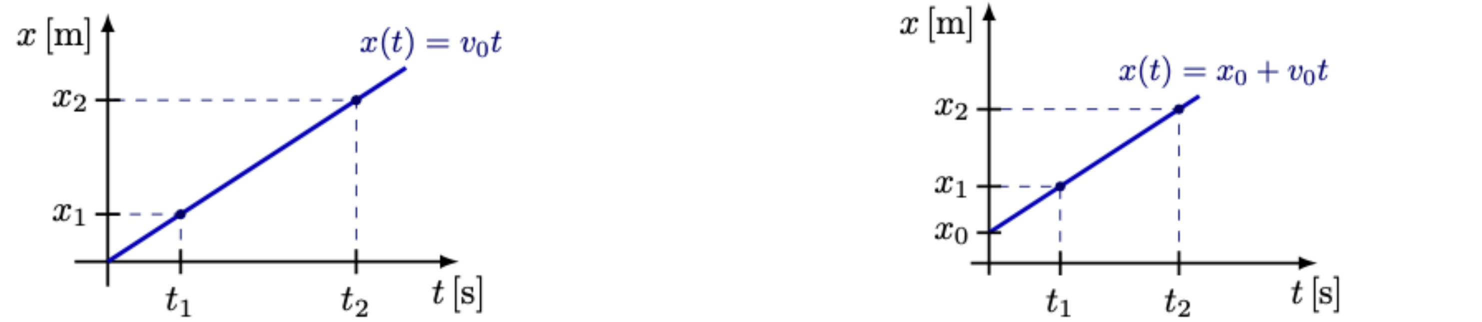
$$\left.\begin{aligned} x &= x(t) \\ y &= y(t) \\ z &= z(t) \end{aligned}\right\}$$ means that the formula depends on time.

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

The motion of a vector in 3-D 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

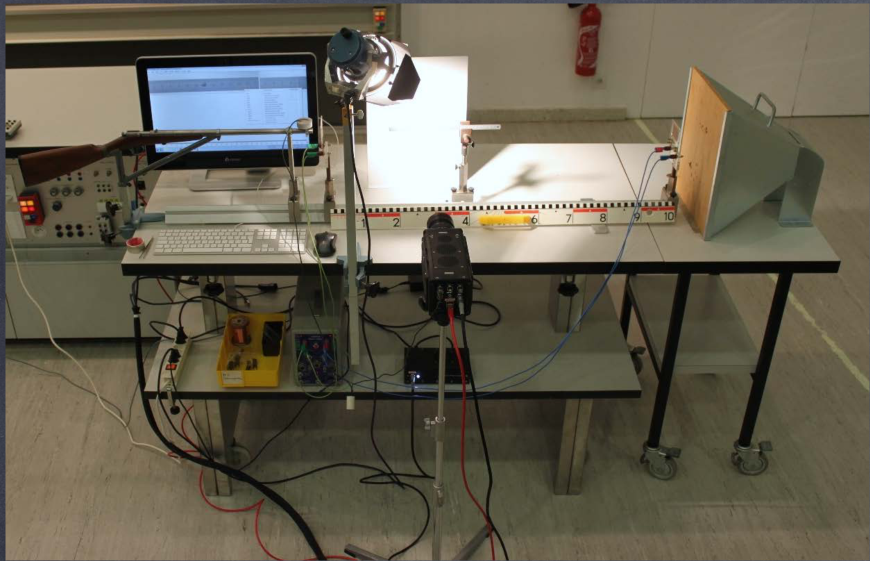
$$V = V_0 = \frac{x_2 - x_1}{t_2 - t_1}$$

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

constant velocity,
1 direction

Is our bullet faster than the speed of sound?

$\left(v = 343 \ \frac{m}{s}\right)$



$\Delta t =$

$\Delta t =$ 4ϵ-5s (25000 frames/s)

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

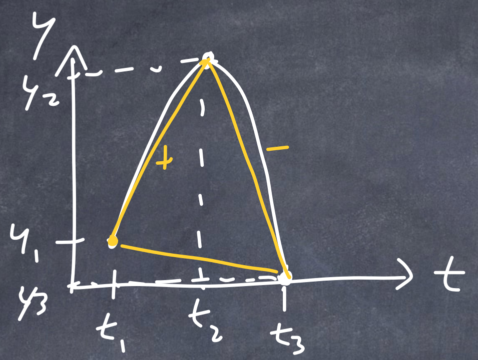
$$\langle \Delta x \rangle = \frac{(\qquad)\text{cm}}{3} =$$

sample standard deviation $= \underset{\text{"sigma"}}{\sigma_{\Delta x}} = \sqrt{\frac{\sum_{i=1}^{n} (\langle \Delta x \rangle - x_i)^2}{n-1}} = \sqrt{\frac{(\quad)^2 + (\quad)^2 + (\quad)^2}{2}}$

This is the uncertainty in the Δx measurement $=$

$$v = \frac{\Delta x}{\Delta t} \quad \text{so} \quad v =$$

what if velocity changes?



$\uparrow +y$ ball thrown vertically

we can calculate an average velocity between any 2 points:

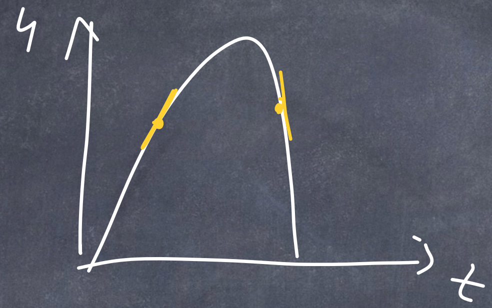
$t_1 \to t_2$: $\quad V = \dfrac{y_2 - y_1}{t_2 - t_1}$ $\quad$ + slope

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

$t_1 \to t_3$ $\quad V = \dfrac{y_3 - y_1}{t_3 - t_1}$

+ and − indicate the direction of the velocity along the y-axis (since velocity is a vector)

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



the tangent to the curve of distance vs. time is the <u>instantaneous velocity</u>

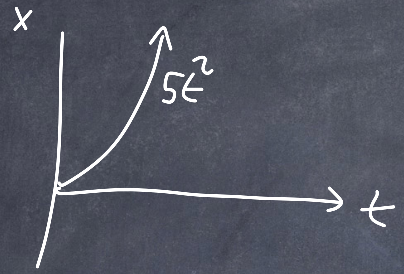
As $\Delta t \to 0$ (Δt approaches 0)

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

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

Speed is a scalar, not a vector quantity (always positive)

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



Let's calculate $v(t)$ from first principles.

$$x(t) = 5t^2$$

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

$$x(t + \Delta t) =$$

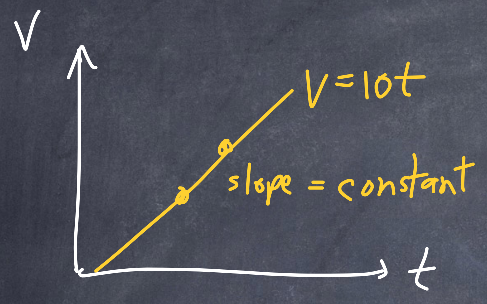
The change $\Delta x = x(t+\Delta t) - x(t)$

average velocity $\frac{\Delta x}{\Delta t} =$

the instantaneous velocity?

$$V = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = 10t + 5\cancel{\Delta t}^{\,\to 0}$$

$$V = 10t$$



what about the acceleration?

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

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

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

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

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

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

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

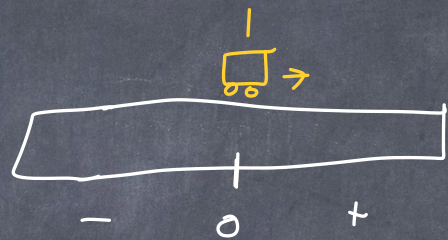
MAT 182

General rules for derivatives.

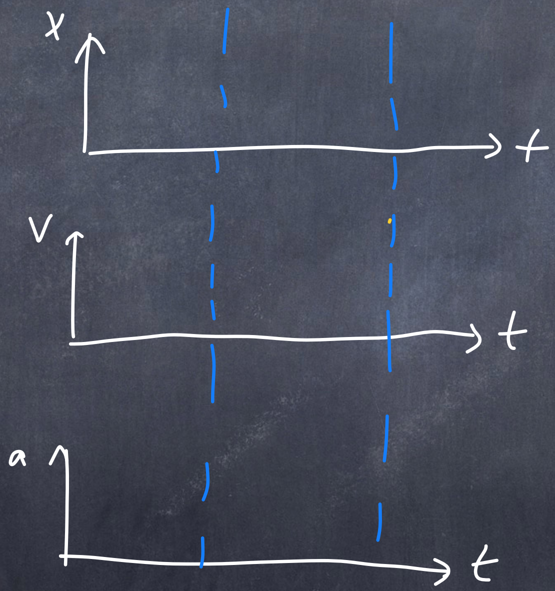
If $x = ct^n$

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

Previous example:



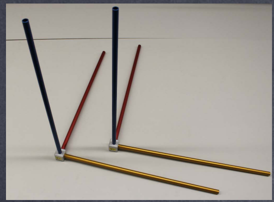
Air car experiment

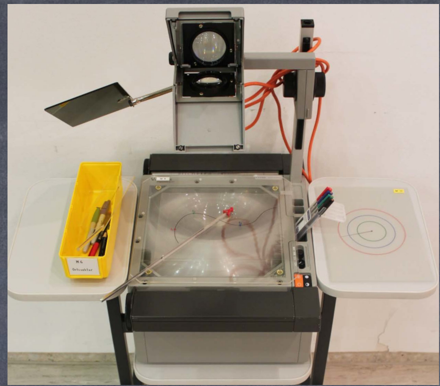


velocity is the slope of x vs. t

acceleration is the slope of v vs. t

Experiments


M1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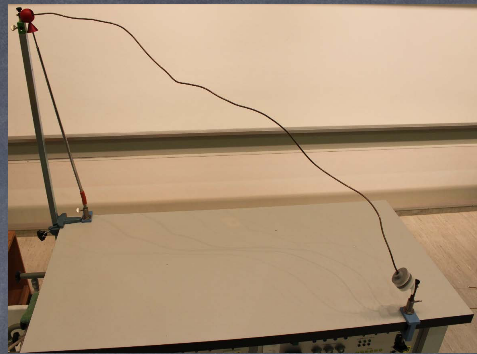
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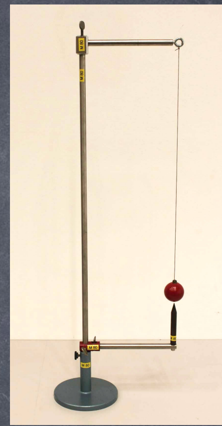
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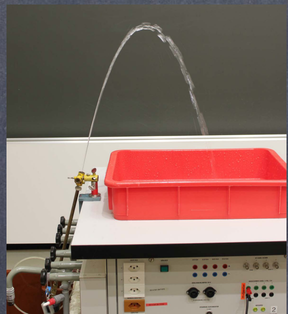
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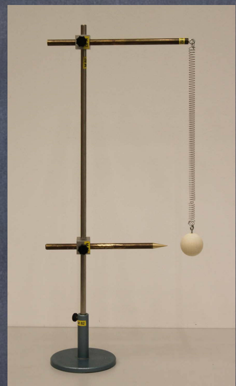
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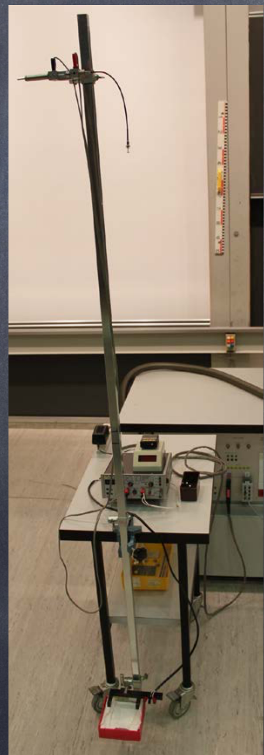
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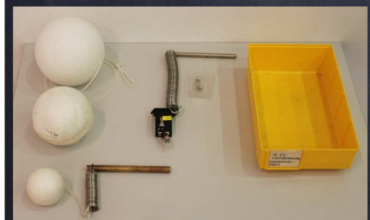
M198


M27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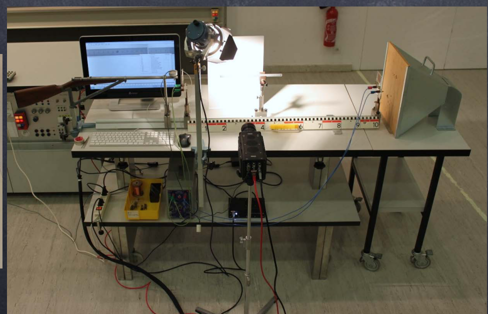
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