Introduction to Physics I

For Biologists, Geoscientists, & Pharmaceutical Scientists

Instructors

- Professors
  - Martino Poggio
  - Michel Calame

- Lectures
  - Roland Steiner

- Exercises/Exam
  - Tobias Meier

Format

- **Lectures**: Thursdays and Fridays 10:00 – 12:00, Grosser Hörsaal
- **Weekly Exercise Sessions**: Schedule on website/ADAM
- **Final Exam**: 02.02.2018, 9:00 – 11:00
- **Language**: English (equivalent materials also available in German)

Weekly Exercise Sessions

- Exercise Sessions are **optional**, but recommended
- Exercises sheets and solutions will be in English **and** German
- Exercise sheets and solutions will be published on website/ADAM
- Sessions start Tuesday & Wednesday 28 & 29.09.2017
- Students are distributed in an alphabetical order among their study program (Bio, Pharma, Geo).

Weekly Exercise Sessions

Exercise classes Physics I

Pharmacy Tuesday, 8:15 – 10:00 h	**Pharma 1** Giulio Romagnoli Biozentrum Hörsaal 103 Last names: A – D	**Pharma 2** Gulibusitan Abulizi Anorganische Chemie Kolloquiumsraum AC006 Last names: E – Kl	**Pharma 3** Sigurd Flagan Pharmazentrum Hörsaal 2 Last names: Ko – P	**Pharma 4** Carl Drechsel Bernoullianum 32 Kleiner Hörsaal 120 Last names: R – Z
Biology **and other studies (B.A.)** Wednesday, 14:15 – 16 h	**Bio 1** Marcus Wyss Pharmazentrum Hörsaal 2 Last names: A – F	**Bio 2** Benjamin Petrak Anorganische Chemie Kolloquiumsraum AC006 Last names: G – L	**Bio 3** Olena Synhaivska Biozentrum Hörsaal 103 Last names: M – R	**Bio 4** Christian Meier Physikalische Chemie Grosser Hörsaal 3.10 Last names: S – Z
Geosciences	**Geo 1** Nicola Rossi Biozentrum Hörsaal 102 Wednesday, 17 – 18:45 h Last names: A – L	**Geo 2** Yves Mermoud Physik Alter Hörsaal 1.22 Wednesday, 16:30-18:15 h Last names: M – Z	UNI BASEL	Departement Physik Universität Basel Prof. M. Poggio / PD Dr. M. Calame T. Meier / C. Drechsel tobias.meier@unibas.ch c.drechsel@unibas.ch Büro 3.04 Tel.: 061 207 37 30 http://adam.unibas.ch

Exam

- The exam is on 02.02.2018 from 9:00 – 11:00
- It covers all topics from the lecture and exercise sessions
- The exam will be in English **and** German
- Allowed Items:
  - Pocket calculator
  - One A4 sheet with handwritten notes on both sides
  - A formulary (small book with formulas)
  - A dictionary
  - Devices with wireless internet access are strictly **forbidden**
- More information can be found at: https://philnat.unibas.ch/examen/

Literature

- *Physik für Mediziner, Biologen, Pharmazeuten, 8. Auflage* by Trautwein, Kreibig, and Hüttermann (German)
  - PDF available on course website/ADAM
- *Physics for Scientists and Engineers, Vol. 1, 6th Edition* by Paul A. Tipler, Gene Mosca (English)
- Skriptum (German)
  - Hard copy available for purchase **and** PDF available on course website/ADAM
- Lecture Notes (English)
  - PDFs will be available on course website after each lecture

Physik für Mediziner, Biologen, Pharmazeuten, 8. Auflage by Trautwein, Kreibig, and Hüttermann

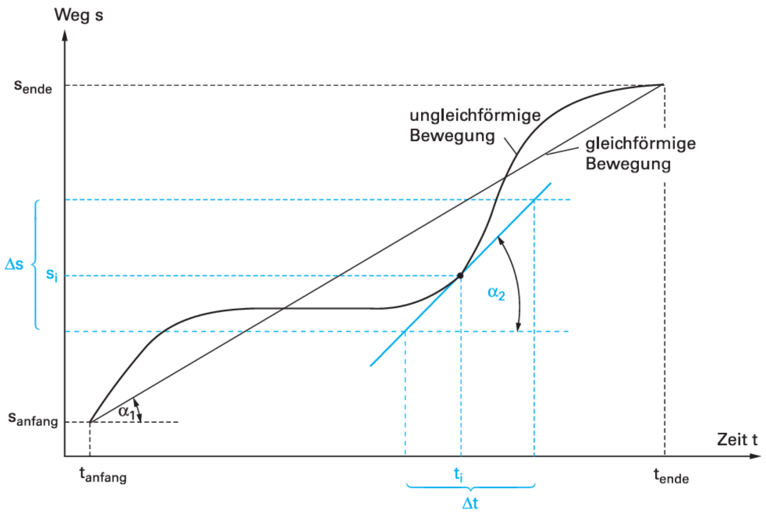


Abb. 1.5 Weg-Zeit-Diagramm bei ungleichförmiger Bewegung.

dass Körper keine beliebig hohe Geschwindigkeit annehmen können, dass vielmehr eine Grenzgeschwindigkeit existiert, die sich als die Ausbreitungsgeschwindigkeit von elektromagnetischen Wellen im Vakuum, c, ergibt. Da v also stets kleiner oder gleich c sein muss, ist Gl. (1-12) abzuändern, und aus der Relativitätstheorie folgt die Additionsbeziehung:

$$v = \frac{v_1 + v_2}{1 + \frac{v_1 v_2}{c^2}} . \qquad (1\text{-}13)$$

Sind v_1 und v_2 gegenüber Lichtgeschwindigkeit c sehr klein (so dass $v_1 v_2/c^2$ gegenüber 1 vernachlässigt werden kann), dann geht Gl. (1-13) in die gewohnte Gl. (1-12) über. Nur unter dieser Voraussetzung darf also Gl. (1-12) benutzt werden. Dass die angegebene Additionsbeziehung dem Postulat der Grenzgeschwindigkeit c Rechnung trägt, erkennt man, wenn man eine der beiden Geschwindigkeiten oder aber beide gleich c setzt. Dann ergibt sich als resultierende Geschwindigkeit jeweils c.

1.2.2 Beschleunigung

Um Änderungen der Geschwindigkeit während des Bewegungsvorganges beschreiben zu können, führt man den Begriff der *Beschleunigung* ein.

Die *Geschwindigkeit* beschreibt die Änderung der zurückgelegten Wegstrecke mit der Zeit, und die *Beschleunigung* die Änderung der Geschwindigkeit mit der Zeit.

Zunächst führen wir zur näherungsweisen Beschreibung der Beschleunigung die *mittlere Beschleunigung* a_{mittel} analog zur Definition der mittleren Geschwindigkeit von Gl. (1-10) ein. Wir bilden dazu das Verhältnis der Geschwindigkeit $\Delta v = v_2 - v_1$ zwischen zwei Orten s_2 und s_1 und dem zum Zurücklegen der Strecke $\Delta s = s_2 - s_1$ benötigten Zeitintervall $\Delta t = t_2 - t_1$:

$$a = \frac{\Delta v}{\Delta t} . \qquad (1\text{-}14)$$

Aus diesem Mittelwert über das *Zeitintervall* Δt erhalten wir die Beschleunigung $a(t_i)$ zum Zeit*punkt* t_i dadurch, dass wir Δt beliebig klein wählen und damit vom Differenzenquotienten der Gl. (1-14) zum Differentialquotienten

$$\lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt} = a(t_i) \qquad (1\text{-}15)$$

übergehen. Die SI-Einheit von a ist m s^{-2}.

Die Geschwindigkeit kann entweder zu- oder abnehmen, d. h., dv und damit auch a können positiv oder negativ sein. Entsprechend unterscheiden wir zwischen Beschleunigung und Abbremsung *(negative Beschleunigung)*.

Die Beschleunigung dv/dt lässt sich nach Gl. (1-11) auch schreiben

$$\frac{dv}{dt} = \frac{d(ds/dt)}{dt} ;$$

d. h., der Weg s wird zweifach nach der Zeit differenziert. Dafür verwenden wir auch die formale Schreibweise:

$$a = \frac{dv}{dt} = \frac{d^2 s}{dt^2} . \qquad (1\text{-}16)$$

In Gl. (1-14) und (1-15) haben wir die Skalare Δv und dv benutzt, und entsprechend hat sich für a in Gl. (1-16) ein Skalar ergeben. Diese Beschränkung auf Beträge ist nur bei der *geradlinigen* Bewegung zulässig. Im allgemeinen Fall der *krummlinigen* Bewegung müssen wir den Vektorcharakter der Geschwindigkeit berücksichtigen, und wir erhalten anstelle von Gl. (1-16)

$$\vec{a} = \frac{d\vec{v}}{dt} . \qquad (1\text{-}17)$$

Der Vektor $\vec{a}$ enthält jetzt sowohl die Änderung des Betrages als auch der Richtung von $\vec{v}$; er weist in Richtung von $d\vec{v}$, fällt also im Allgemeinen nicht mit der Bahnrichtung zusammen. Eine krummlinige Bewegung ist demnach immer eine beschleunigte Bewegung.

Ist $\vec{a}$ während eines Bewegungsvorgangs konstant, ändern sich also weder die Richtung noch der Betrag der Beschleunigung, so sprechen wir von einer *geradlinig gleichförmig beschleunigten Bewegung.*

Ändert sich Betrag oder Richtung der Beschleunigung, so nennen wir die Bewegung *ungleichförmig beschleunigt.*

1.2.3 Kreisbewegung

Geschwindigkeit bei der Kreisbewegung Eine Bewegung, bei der sich die Richtung des Geschwindigkeitsvektors ändert, nennen wir *krummlinig.* Als Sonderfall behandeln wir den auf einer Kreisbahn umlaufenden Punkt P. Die Bewegung von P lässt sich besonders einfach beschreiben, wenn wir statt der kartesischen Koordinaten x und y die Polarkoordinaten r und φ verwenden (Abb. 1.6), wobei r der Betrag des Radiusvektors $\vec{r}$ und φ der von der x-Achse aus in der Einheit Radiant gemessene ebene Winkel sind. Da r bei der Kreisbewegung unverändert bleibt, können wir den Bewegungsablauf durch die Änderung von φ mit der Zeit t erfassen.

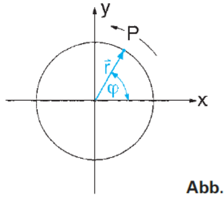


Abb. 1.6 Kreisbewegung.

Den Differentialquotienten $d\varphi/dt$ definieren wir als Betrag der *Winkelgeschwindigkeit* $\vec{\omega}$ *(Kreisfrequenz)*:

$$\frac{d\varphi}{dt} = \omega, \text{ mit der SI-Einheit rad s}^{-1} \qquad (1\text{-}18\,a)$$

Wollen wir neben der Kreisfrequenz ω noch Drehachse und Drehsinn angeben, so fassen wir diese drei Angaben in dem Vektor der Winkelgeschwindigkeit $\vec{\omega}$ zusammen. Der Vektor $\vec{\omega}$ ist so definiert, dass seine Länge ein Maß für die Kreisfrequenz ist und die Richtung die Stellung der Drehachse und den Drehsinn der Bewegung angibt (Abb. 1.7). Entsprechend kann auch der Winkel $\vec{\varphi}$ als Vektor definiert werden.

Anmerkung Vektoren von der Art von $\vec{\omega}$ und $\vec{\varphi}$ unterscheiden sich von den in Kap. 1.2.1 eingeführten Orts- oder Geschwindigkeitsvektoren dadurch, dass ihre Richtung die Richtung einer Drehachse und den Drehsinn angibt. Zur deutlichen Unterscheidung nennt man $\vec{\omega}$ und $\vec{\varphi}$ auch *axiale Vektoren.*

Physics for Scientists and Engineers, Vol. 1, 6th Edition by Paul A. Tipler, Gene Mosca

average velocity for the run is 0.250 km/min, which we compute using the definition of average velocity ($v_{av\,x} = \Delta x/\Delta t$). The runner starts from rest ($v_{1x} = 0$), and during the first one or two seconds his velocity increases rapidly, reaching a constant value v_{2x} that is sustained for the remainder of the run. The value of v_{2x} is just slightly greater than 0.250 km/min, so Equation 2-16 gives a value of about 0.125 km/min for the average velocity, a value almost 50% below the value given by the definition of average velocity. Equation 2-16 is not applicable because the acceleration does not remain constant for the entire run.

Equations 2-12, 2-14, 2-15, and 2-16 can be used to solve kinematics problems involving one-dimensional motion with constant acceleration. The choice of which equation or equations to use for a particular problem depends on what information you are given in the problem and what you are asked to find. Equation 2-15 is useful, for example, if we want to find the final velocity of a ball dropped from rest at some height x and we are not interested in the time the fall takes.

A falling apple captured by strobe photography at 60 flashes per second. The acceleration of the apple is indicated by the widening of the spaces between the images. *(Estate of Harold E. Edgerton/Palm Press.)*

USING THE CONSTANT-ACCELERATION KINEMATIC EQUATIONS

Review the Problem-Solving Strategy for solving problems using kinematic equations. Then, examine the examples involving one-dimensional motion with constant acceleration that follow.

PROBLEM-SOLVING STRATEGY

1-D Motion with Constant Acceleration

PICTURE Determine if a problem is asking you to find the time, distance, velocity, or acceleration for an object.

SOLVE Use the following steps to solve problems that involve one-dimensional motion and constant acceleration.

1. Draw a figure showing the particle in its initial and final positions. Include a coordinate axis and label the initial and final coordinates of the position. Indicate the + and − directions for the axis. Label the initial and final velocities, and label the acceleration.
2. Select one of the constant-acceleration kinematic equations (Equations 2-12, 2-14, 2-15, and 2-16). Substitute the given values into the selected equation and, if possible, solve for the desired value.
3. If necessary, select another of the constant-acceleration kinematic equations, substitute the given values into it, and solve for the desired value.

CHECK You should make sure that your answers are dimensionally consistent and the units of the answers are correct. In addition, check to make sure the magnitudes and signs of your answers agree with your expectations.

Problems with one object We will begin by looking at several examples that involve the motion of a single object.

Example 2-9 A Car's Stopping Distance

On a highway at night you see a stalled vehicle and brake your car to a stop. As you brake, the velocity of your car decreases at a constant rate of (5.0 m/s)/s. What is the car's stopping distance if your initial velocity is (*a*) 15 m/s (about 34 mi/h) or (*b*) 30 m/s?

PICTURE Use the Problem-Solving Strategy that precedes this example. The car is drawn as a dot to indicate a particle. We choose the direction of motion as $+x$ direction, and we choose

the initial position $x_0 = 0$. The initial velocity is $v_{0x} = +15$ m/s and the final velocity $v_x = 0$. Because the velocity is decreasing, the acceleration is negative. It is $a_x = -5.0$ m/s². We seek the distance traveled, which is the magnitude of the displacement Δx. We are neither given nor asked for the time, so $v_x^2 = v_{0x}^2 + 2a_x\,\Delta x$ (Equation 2-15) will provide a one-step solution.

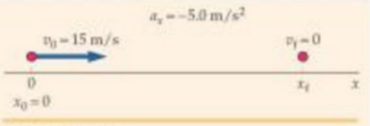


FIGURE 2-14

SOLVE

(*a*) 1. Draw the car (as a small dot) in its initial and final positions (Figure 2-14). Include a coordinate axis and label the drawing with the kinematic parameters.

2. Using Equation 2-15, calculate the displacement Δx:

$$v_x^2 = v_{0x}^2 + 2a_x\,\Delta x$$
$$0 = (15\text{ m/s})^2 + 2(-5.0\text{ m/s}^2)\Delta x$$
$$\Delta x = 22.5\text{ m} = \boxed{23\text{ m}}$$

(*b*) Substitute an initial speed of 30 m/s into the expression for Δx obtained in Part (*a*) (see Figure 2-14):

$$v_x^2 = v_{0x}^2 + 2a_x\,\Delta x$$
$$0 = (30\text{ m/s})^2 + 2(-5.0\text{ m/s}^2)\Delta x$$
$$\Delta x = \boxed{90\text{ m}}$$

CHECK The car's velocity decreases by 5.0 m/s each second. If its initial velocity is 15 m/s, it would take 3.0 s for it to come to rest. During the 3.0 s, it has an average velocity of half 15 m/s, so it would travel $\frac{1}{2}$(15 m/s)(3.0 s) = 23 m. This confirms our Part (*a*) result. Our Part (*b*) result can be confirmed in the same manner.

Example 2-10 Stopping Distance *Try It Yourself*

In the situation described in Example 2-9, (*a*) how much time does it take for the car to stop if its initial velocity is 30 m/s, and (*b*) how far does the car travel in the last second?

PICTURE Use the Problem-Solving Strategy that precedes Example 2-9. (*a*) In this part of the problem, you are asked to find the time it takes the car to stop. You are given the initial velocity $v_{0x} = 30$ m/s. From Example 2-9, you know the car has an acceleration $a_x = -5.0$ m/s². A relationship between time, velocity, and acceleration is given by Equation 2-12. (*b*) Because the car's velocity decreases by 5.0 m/s each second, the velocity 1.0 s before the car stops must be 5.0 m/s. Find the average velocity during the last second and use that to find the distance traveled.

SOLVE

Cover the column to the right and try these on your own before looking at the answers.

Steps	Answers
(*a*) 1. Draw the car (as a small dot) in its initial and final positions (Figure 2-15). Include a coordinate axis and label the drawing with the kinematic parameters.	
2. Use Equation 2-12 to find the total stopping time Δt.	$\Delta t = \boxed{6.0\text{ s}}$
(*b*) 1. Draw the car (as a small dot) in its initial and final positions (Figure 2-16). Include a coordinate axis.	
2. Find the average velocity during the last second from $v_{av\,x} = \frac{1}{2}(v_{1x} + v_{fx})$.	$v_{av\,x} = 2.5$ m/s
3. Compute the distance traveled from $\Delta x = v_{av\,x}\,\Delta t$.	$\Delta x = v_{av\,x}\,\Delta t = \boxed{2.5\text{ m}}$

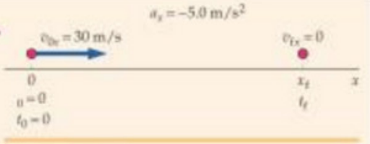


FIGURE 2-15

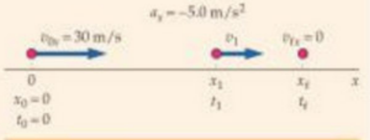


FIGURE 2-16

CHECK We would not expect the car to travel very far during the last second because it is moving relatively slowly. The Part (*b*) result of 2.5 m is a plausible result.

Skriptum

Das bedeutet, dass der Gesamtimpuls eines abgeschlossenen Systems konstant ist.

Impulssatz

In einem abgeschlossenen System gilt :

$$\sum_{i=1}^{n} \vec{p}_i = \vec{p}_{tot} = \text{konstant}$$

3.4 Die Gravitationskraft

Experimentelle Beobachtung:

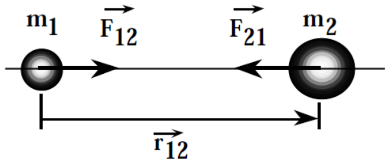
Massen üben aufeinander anziehende Kräfte aus

Beispiele :

Erde - Sonne, Gravitationswaage von Cavendish

$\vec{F}_{12} = -\vec{F}_{21}$

(Reaktionsprinzip)



Gravitationsgesetz von Newton

$$|\vec{F}| = \gamma \frac{m_1 \cdot m_2}{r^2} \qquad \gamma = 6.67 \cdot 10^{-11} \frac{Nm^2}{kg^2}$$

γ : Gravitationskonstante

oder vektoriell geschrieben

$$\vec{F}_{12} = \gamma \frac{m_1 \cdot m_2}{r^3} \vec{r}_{12}$$

m_1, m_2 bedeuten hier 'schwere' Massen.
Wie bereits oben erwähnt sind jedoch 'schwere' und 'träge' Massen (experimentell) identisch.

Das Gravitationsfeld

Der Begriff 'Feld' bedeutet, dass jedem Punkt im Raum ein Wert einer physikalischen Grösse (Skalar oder Vektor) zugeordnet wird.

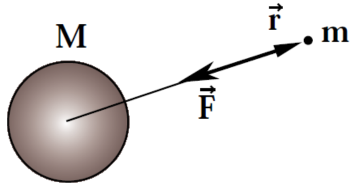
Beispiele von Feldern :

Kraft, Geschwindigkeit, Temperatur, Druck, elektrische Feldstärke

Definition des Gravitationsfelds $\vec{G}$ einer Masse M:

$$\vec{G} = \frac{\text{Gravitationskraft auf Probemasse m}}{\text{Probemasse m}}$$

$$|\vec{G}| = \frac{F}{m} = \gamma \frac{M \cdot m}{r^2\, m} = \gamma \frac{M}{r^2}$$



Richtung von $\vec{G}$: Richtung $-\vec{r}$

Die Masse M verändert den sie umgebenden Raum durch das Gravitationsfeld. Dieses kann mit einer Probemasse (m) nachgewiesen werden.

Gravitationsfeld der Erde

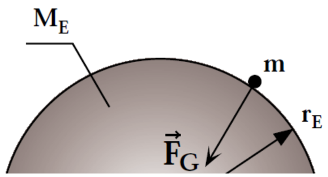
Gravitationskraft auf m:

$$F_G = \gamma \frac{mM_E}{r_E^2}$$

Gravitationsfeld von M_E auf Erdoberfläche:

$$G(r_E) = \gamma \frac{M_E}{r_E^2} = 6.67 \cdot 10^{-11} \frac{6 \cdot 10^{24}}{(6.4 \cdot 10^6)^2} \left[\frac{N}{kg}\right]$$

$$G(r_E) = 9.8 \left[\frac{N}{kg}\right] \equiv \left[\frac{m}{s^2}\right]$$



Das Gewicht einer Masse m = 1 kg beträgt somit 9.8 N.

Course Website

- http://poggiolab.unibas.ch/courses/physics-i-for-biologists-fall-2017/

POGGIO LAB

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Physics I for Biologists (Fall 2017)

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OVERVIEW

This is the first semester of the required physics course for biologists, pharmacists, and geologists. The main subjects covered are mechanics and thermodynamics. Knowledge of high school level mathematics is required, including understanding of basic geometry, trigonometry, vectors, and calculus (derivatives and integrals). See university Course Directory.

FORMAT AND REQUIREMENTS

The course consists of two 2-hour lectures per week and one 2-hour exercise session per week. Optional exercises will be assigned and reviewed in the exercise sessions throughout the semester. The final exam is based on and resembles these exercises. The lectures and exercise sessions are conducted in English. Whenever possible, all course materials, including exercises and the final exam will be available in both English and German. The instructors are Prof. Martino Poggio and Prof. Michel Calame (more information).

LITERATURE

The course is based on *Physik für Mediziner, Biologen, Pharmazeuten, 8. Auflage* (pdf) by Trautwein, Kreibig, and Hüttermann (De Gruyter, 2014) in German. The recommended English textbook is *Physics for Scientists and Engineers, Vol. 1, 6th Edition* by Paul A. Tipler, Gene Mosca (Freeman and Co., 2008) or – for a full version including material beyond this course – *Physics for Scientists and Engineers, 6th Edition* by Paul A. Tipler, Gene Mosca (Freeman and Co., 2008). Specific readings in both books are recommended in preparation for each lecture below. In addition, a German skriptum which covers the topics of the course can be purchased in class or downloaded (pdf). A German version of the Tipler text book, *Physik für Wissenschafter und Ingenieure, 7. Auflage* (pdf) by Paul A. Tipler, Gene Mosca, and Jenny Wagner (Springer, 2008), is available in online form as is a work book, *Arbeitsbuch zu Tipler/Mosca Physik* (pdf) by David Mills and Alexander Knochel (Springer, 2008), with practice problems and solutions.

SCHEDULE

Lectures: Thursdays and Fridays, 10.00-12.00, Grosser Hörsaal

21.09.2017

INTRODUCTION AND MATH REVIEW

Introduction; course organization, outline and expectations; literature; mathematical review: vectors, geometry, trigonometry, derivatives, integrals.

Trautwein Reading (German): chapters A.3, A.5

Tipler Reading (English): chapters 1-6, 1-7, M-7, M-8, M-11, M-12

Instructor: Prof. Poggio

Downloads: Lecture slides and notes

22.09.2017

PHYSICAL QUANTITIES

Physical quantities; units; measurements.

Trautwein Reading (German): chapter 1. to 1.1.5

Tipler Reading (English): chapters 1-1, 1-2, 1-3, 1-4, 1-5

Instructor: Prof. Poggio

Downloads: Lecture slides and notes, Exercise sheet 1 (English) / Blatt 1 (Deutsch), Solutions 1 (English) / Lösungen 1 (Deutsch)

28.09.2017

SPACE AND TIME I

Motion in space; velocity; acceleration.

Trautwein Reading (German): chapter 1.2 to 1.2.4

Tipler Reading (English): chapters 2, 3

Instructor: Prof. Calame

Downloads: Lecture slides and notes

29.09.2017

SPACE AND TIME II

Motion under constant acceleration; circular motion.

Trautwein Reading (German): chapter 1.2 to 1.2.4

Tipler Reading (English): chapters 2, 3

Instructor: Prof. Calame

Downloads: Lecture slides and notes, Exercise sheet 2 (English) / Blatt 2 (Deutsch), Solutions 2 (English) / Lösungen 2 (Deutsch)

05.09.2017

MASS AND FORCE I

Mass; inertia; Newton's Laws; gravity; inertial forces.

Trautwein Reading (German): chapter 2. to 2.2.5

Tipler Reading (English): chapter 4

Instructor: Prof. Poggio

Downloads: Lecture slides and notes

06.10.2017

MASS AND FORCE II

Torque; moment of inertia; angular momentum; center of mass.

Trautwein Reading (German): chapter 2.2.6 to 2.2.9

Tipler Reading (English): chapter 5

Instructor: Prof. Poggio

Downloads: Lecture slides and notes, Exercise sheet 3 (English) / Blatt 3 (Deutsch), Solutions 3 (English) / Lösungen 3 (Deutsch)

12.10.2017

WORK, ENERGY, AND POWER

Friction; work; energy; power; forms of energy and power.

Trautwein Reading (German): chapter 3

Tipler Reading (English): chapter 6

Instructor: Dr. Groß

Downloads: Lecture slides and notes

13.10.2017

CONSERVATION LAWS I

Conservation of energy; conservation of momentum.

Trautwein Reading (German): chapter 4. to 4.3

Tipler Reading (English): chapters 7, 8 (excluding 7-4, 7-5)

Instructor: Dr. Braakman

Downloads: Lecture slides and notes, Exercise sheet 4 (English) / Blatt 4 (Deutsch), Solutions 4 (English) / Lösungen 4 (Deutsch)

19.10.2017

CONSERVATION LAWS II

Conservation of angular momentum.

Trautwein Reading (German): chapter 4.4

Tipler Reading (English): chapters 9, 10 (excluding 10-4)

Instructor: Prof. Poggio

Downloads: Lecture slides and notes

20.10.2017

MECHANICAL PROPERTIES OF SOLIDS

Binding; molecular picture; forms of matter; properties of solids.

Trautwein Reading (German): chapter 5. to 5.2

Tipler Reading (English): chapters 37, 38-1, 12

Instructor: Prof. Poggio

Downloads: Lecture slides and notes, Exercise sheet 5 (English) / Blatt 5 (Deutsch), Solutions 5 (English) / Lösungen 5 (Deutsch)

26.10.2017

MECHANICAL PROPERTIES OF LIQUIDS I

Properties of liquids, surface tension; hydrostatics; capillary forces.

Trautwein Reading (German): chapter 5.3 to 5.3.2.1

Tipler Reading (English): chapter 13

Instructor: Prof. Poggio

Downloads: Lecture slides and notes

27.10.2017

MECHANICAL PROPERTIES OF LIQUIDS II

Pressure in fluids; hydrodynamics; continuity equation.

Trautwein Reading (German): chapter 5.3.2.2 to 5.3.3.1

Tipler Reading (English): chapter 13

Instructor: Prof. Poggio

Downloads: Lecture slides and notes, Exercise sheet 6 (English) / Blatt 6 (Deutsch), Solutions 6 (English) / Lösungen 6 (Deutsch)

02.11.2017

MECHANICAL PROPERTIES OF LIQUIDS III

Viscosity; laminar flow; turbulence.

Trautwein Reading (German): chapter 5.3.3.2 to 5.3.3.2.4

Tipler Reading (English): chapter 13

Instructor: Prof. Calame

Downloads: Lecture slides and notes

03.11.2017

NANOTECHNOLOGY

Nanomaterials; scaling laws; why nano?

Trautwein Reading (German): chapter 5.4

Tipler Reading (English):

Instructor: Prof. Calame

Downloads: Lecture slides and notes, Exercise sheet 7 (English) / Blatt 7 (Deutsch), Solutions 7 (English) / Lösungen 7 (Deutsch)

09.11.2017

MECHANICAL VIBRATIONS I

Harmonic oscillators; pendulum; undamped oscillator; damped oscillator; driven oscillations.

Trautwein Reading (German): chapter 6. to 6.4

Tipler Reading (English): chapter 14

Instructor: Prof. Calame

Downloads: Lecture slides and notes

10.11.2017

MECHANICAL VIBRATIONS II

Anharmonic oscillations; superposition; decomposition; beating; coupled pendulum.

Trautwein Reading (German): chapter 6.5 to 6.6

Tipler Reading (English): chapter 14

Instructor: Prof. Calame

Downloads: Lecture slides and notes, Exercise sheet 8 (English) / Blatt 8 (Deutsch), Solutions 8 (English) / Lösungen 8 (Deutsch)

16.11.2017

WAVES I

Propagation of vibrations; acoustics; Doppler effect.

Trautwein Reading (German): chapter 7. to 7.4

Tipler Reading (English): chapter 15

Instructor: Prof. Poggio

Downloads: Lecture slides and notes

17.11.2017

WAVES II

Damped waves; anharmonic waves; superposition of waves; Huygens' principle.

Trautwein Reading (German): chapter 7.5 to 7.8

Tipler Reading (English): chapter 15

Instructor: Prof. Poggio

Downloads: Lecture slides and notes, Exercise sheet 9 (English) / Blatt 9 (Deutsch), Solutions 9 (English) / Lösungen 9 (Deutsch)

23.11.2017

WAVES III

Interfaces; standing waves; music; human voice; ultrasound.

Trautwein Reading (German): chapter 7.9 to 7.13

Tipler Reading (English): chapter 16

Instructor: Prof. Poggio

Downloads: Lecture slides and notes, Exercise sheet 10 (English) / Blatt 10 (Deutsch), Solutions 10 (English) / Lösungen 10 (Deutsch)

24.11.2017

DIES ACADEMICUS

No lecture.

30.11.2017

HEAT AND TEMPERATURE

Definition of temperature; heat energy; heat capacity; temperature scales; temperature measurements.

Trautwein Reading (German): chapter 8

Tipler Reading (English): chapter 17-1, 17-2, 18-1

Instructor: Prof. Poggio

Downloads: Lecture slides and notes

01.12.2017

MACROSCOPIC THERMAL EFFECTS

Thermal expansion; heat transport; internal energy and introduction to 1st law of thermodynamics

Trautwein Reading (German): chapter 13. to 13.2

Tipler Reading (English): chapter 20-1, 20-4, 18-3

Instructor: Prof. Calame

Downloads: Lecture slides and notes, Exercise sheet 11 (English) / Blatt 11 (Deutsch), Solutions 11 (English) / Lösungen 11 (Deutsch)

07.12.2017

IDEAL GASES

Ideal gas law; change of state; adiabatic changes; gas pressure; kinetic gas theory.

Trautwein Reading (German): chapter 9, 10

Tipler Reading (English): chapter 17-3, 17-4

Instructor: Prof. Calame

Downloads: Lecture slides and notes

08.12.2017

KINETIC GAS THEORY

Kinetic energy and temperature; equipartition; brownian motion; work; heat capacity, real gases.

Trautwein Reading (German): chapter 10, 11

Tipler Reading (English): chapter 17-4, 18-1, 18-2

Instructor: Prof. Calame

Downloads: Lecture slides and notes, Exercise sheet 12 (English) / Blatt 12 (Deutsch), Solutions 12 (English) / Lösungen 12 (Deutsch)

14.12.2017

LAWS OF THERMODYNAMICS I

Internal energy, 1st law; reversible and irreversible processes; entropy.

Trautwein Reading (German): chapter 12.1 to 12.4

Tipler Reading (English): chapter 18-3, 18-4, 18-5, 18-6, 18-7, 18-8, 18-9

Instructor: Prof. Poggio

Downloads: Lecture slides and notes

15.12.2017

LAWS OF THERMODYNAMICS II

2nd law; energy balance; heat engines.

Trautwein Reading (German): chapter 12.5

Tipler Reading (English): chapter 19

Instructor: Prof. Calame

Downloads: Lecture slides and notes, Mock Exam (English) / Test Prüfung (Deutsch), Mock Exam Solutions (English) / Test Prüfung Lösungen (Deutsch)

21.12.2017

THERMAL PROPERTIES OF MATTER

Mixing; solutions; diffusion; osmosis.

Trautwein Reading (German): chapter 13.3 to 13.3.7.6

Tipler Reading (English): 20-2, 20-3

Instructor: Prof. Calame

Downloads: Lecture slides and notes

Why Physics?

- “The *Fundamental* Science”

- Understanding measurement and measurement devices

- Learning to apply the “Scientific Method”

What is Physics?

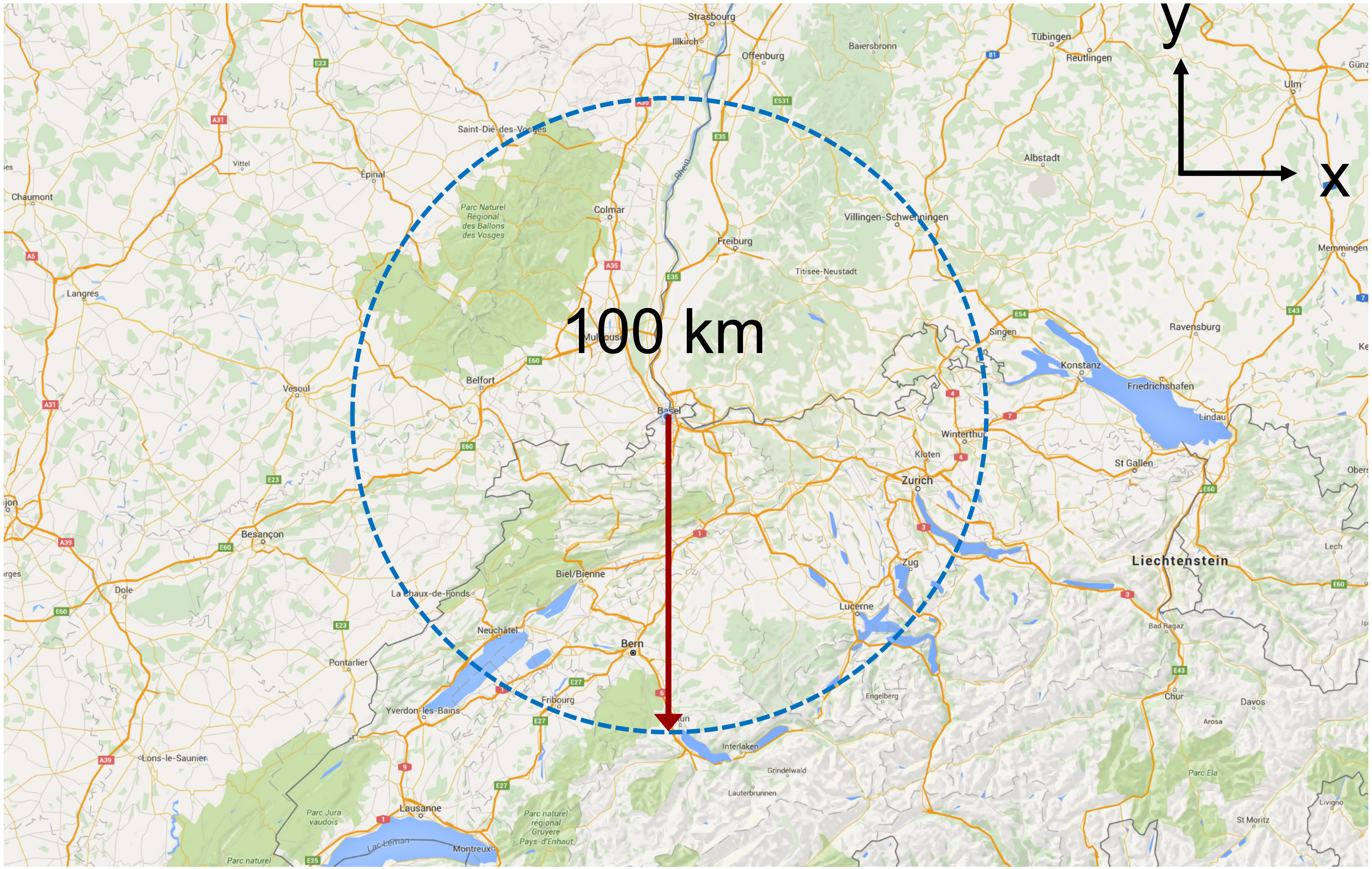
- A model that describes how the universe behaves.
  - Model: fundamental principles and laws
  - Universe: everything around us
  - The model holds everywhere and always

- Experiments are the basis for this model

- The model allows us to make predictions

Mathematical Review

- Vectors
- Geometry
- Trigonometry
- Derivatives
- Integrals



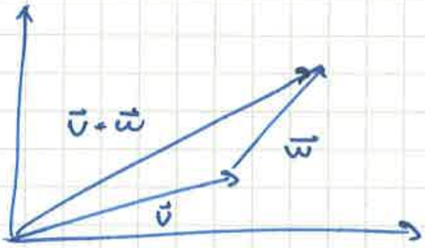
$\vec{d}$ = (0, -100) km

$|\vec{d}|$ = 100 km

Vectors

$$\vec{v} = (v_x, v_y, v_z) \qquad |\vec{v}| = \sqrt{v_x^2 + v_y^2 + v_z^2}$$

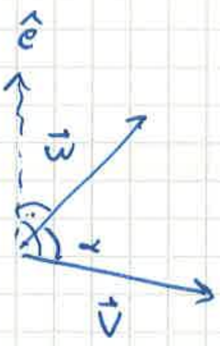
$$\vec{v} + \vec{w} = (v_x + w_x, v_y + w_y, v_z + w_z)$$



$$a\vec{v} = (a v_x, a v_y, a v_z)$$

$$\vec{v} \cdot \vec{w} = |\vec{v}||\vec{w}| \cos\alpha = x$$

$$\vec{v} \times \vec{w} = |\vec{v}||\vec{w}| \sin\alpha \ \hat{e} = \vec{x}$$

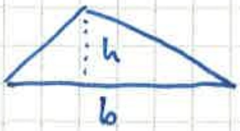


Geometry

Area

a^2

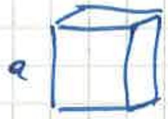
ab



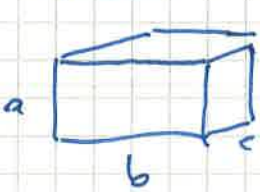
$\frac{bh}{2}$

πr^2

Volume



a^3

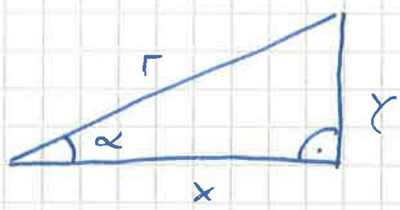


abc

$\frac{abh}{3}$

$\frac{4}{3}\pi r^3$

Trigonometry



$$\sin \alpha = \frac{y}{r}$$

$$\cos \alpha = \frac{x}{r}$$

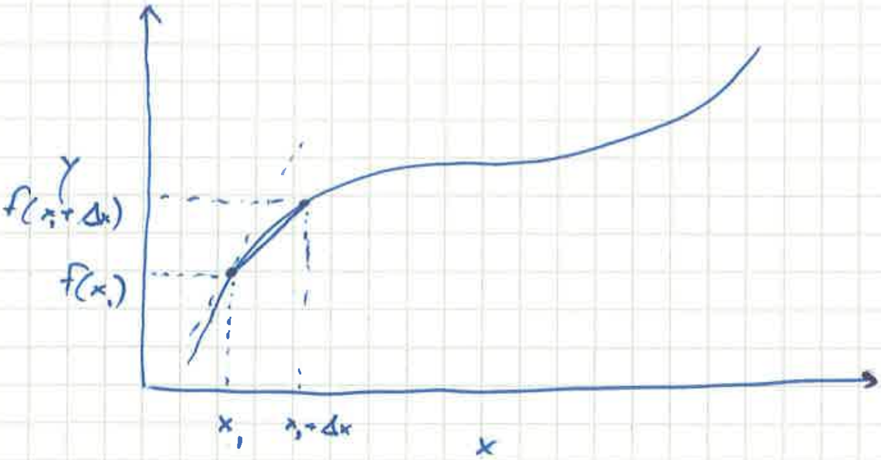
$$\tan \alpha = \frac{y}{x} = \frac{\sin \alpha}{\cos \alpha}$$

$$x^2 + y^2 = r^2$$

$$\frac{x^2}{r^2} + \frac{y^2}{r^2} = \frac{r^2}{r^2}$$

$$\cos^2 \alpha + \sin^2 \alpha = 1$$

Derivatives



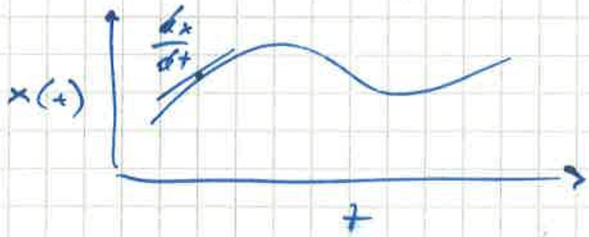
$$y = f(x)$$

$$\frac{\Delta y}{\Delta x} = \frac{f(x_1 + \Delta x) - f(x_1)}{\Delta x}$$

$$y' = \lim_{\Delta x \to 0} \frac{\Delta y}{\Delta x} = \frac{dy}{dx}$$

$$y' = \frac{dy}{dx}$$

$$y'' = \frac{d}{dx}\left(\frac{dy}{dx}\right) = \frac{d^2 y}{dx^2}$$

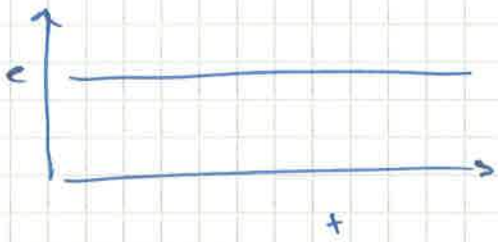


velocity $\rightarrow \frac{dx}{dt} = \dot{x}$

accelloration $\rightarrow \frac{d^2 x}{dt^2} = \ddot{x}$

$$\frac{dc}{dt} = 0$$

constant



$$\frac{d}{dt}\left(c \cdot f(t)\right) = c \cdot \frac{df(t)}{dt}$$

$$\frac{d}{dt}\left(f(t) + g(t)\right) = \frac{df(t)}{dt} + \frac{dg(t)}{dt}$$

$$\frac{d}{dt} f(x(t)) = \frac{df}{dx} \cdot \frac{dx}{dt}$$

$$\frac{d}{dt}\left(f(t) \cdot g(t)\right) = \frac{df(t)}{dt} \cdot g(t) + f(t) \cdot \frac{dg(t)}{dt}$$

$$\frac{d\vec{v}}{dt} = \left(\frac{dv_x}{dt}, \frac{dv_y}{dt}, \frac{dv_z}{dt}\right)$$

$$\dot{\vec{v}} = \left(\dot{v}_x, \dot{v}_y, \dot{v}_z\right)$$

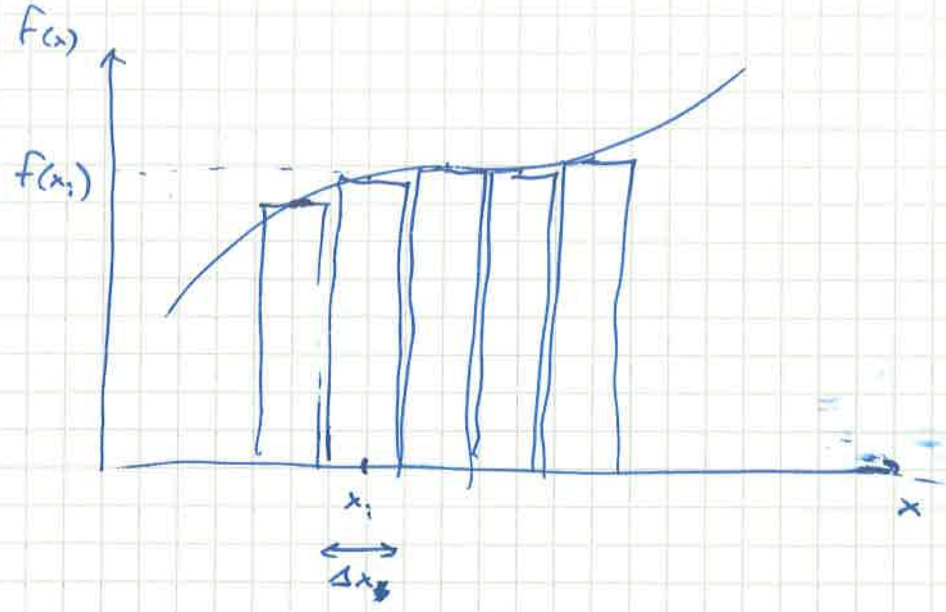
$$\frac{d(t^n)}{dt} = n\,t^{n-1}$$

$$\frac{d}{dt}\sin(\omega t) = \omega \cos(\omega t)$$

$$\frac{d}{dt} e^{at} = a\,e^{at}$$

$$\vdots$$

Integrals



$$\text{Area} = \lim_{\Delta x_i \to 0} \sum_i f(x_i)\,\Delta x_i = \int f(x)\,dx$$

$$g(x) = \int f(x)\,dx = \lim_{\Delta x_i \to 0} \sum_i f(x_i)\,\Delta x_i$$

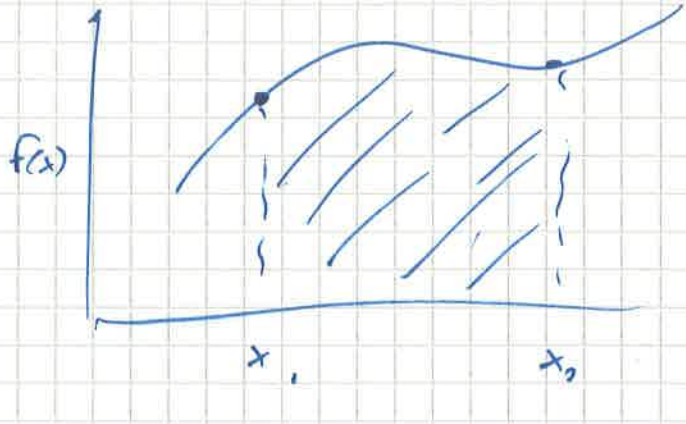
$$g(x) = \sum_i \underbrace{\left(\lim_{\Delta x_i \to 0} f(x_i)\,\Delta x_i \right)}_{\Delta g}$$

$$\Delta g = \lim_{\Delta x \to 0} f(x_i)\,\Delta x = f(x) \lim_{\Delta x \to 0} \Delta x$$

$$f(x) = \lim_{\Delta x \to 0} \frac{\Delta g}{\Delta x} = \frac{d g(x)}{dx}$$

$$f(x) = \frac{d g(x)}{dx} \longleftrightarrow g(x) = \int f(x)\,dx$$

$$\int_{x_1}^{x_2} f(x)\, dx = g(x_2) - g(x_1)$$



$$\int C\, dt = A t$$

$$\int A t^n\, dt = A \frac{t^{n+1}}{n+1} \quad , \quad n \neq -1$$

$$\int e^{at}\, dt = \frac{1}{a} e^{at}$$

$$\int \cos(\omega t)\, dt = \frac{1}{\omega} \sin(\omega t)$$