Introduction to Physics I

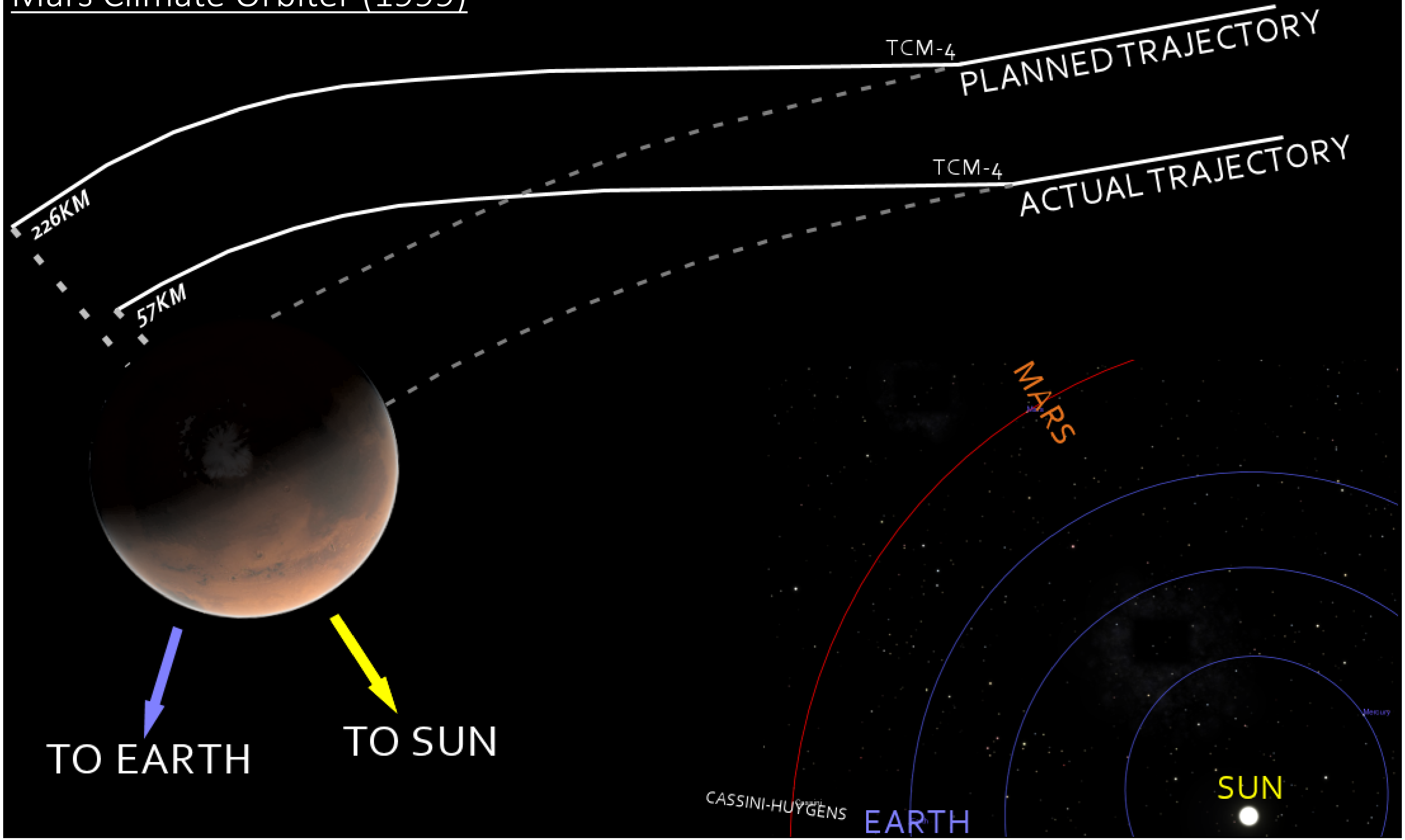
For Biologists, Geoscientists, & Pharmaceutical Scientists

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

Mars Climate Orbiter (1999)



Air Canada 143 (1983)

Meter

Unit of length (meter)

Abbreviations: CGPM, CIPM, BIPM

The origins of the meter go back to at least the 18th century. At that time, there were two competing approaches to the definition of a standard unit of length. Some suggested defining the meter as the length of a pendulum having a half-period of one second; others suggested defining the meter as one ten-millionth of the length of the earth's meridian along a quadrant (one fourth the circumference of the earth). In 1791, soon after the French Revolution, the French Academy of Sciences chose the meridian definition over the pendulum definition because the force of gravity varies slightly over the surface of the earth, affecting the period of the pendulum.

Thus, the meter was intended to equal 10^{-7} or one ten-millionth of the length of the meridian through Paris from pole to the equator. However, the first prototype was short by 0.2 millimeters because researchers miscalculated the flattening of the earth due to its rotation. Still this length became the standard. (The engraving at the right shows the casting of the platinum-iridium alloy called the "1874 Alloy.") In 1889, a new international prototype was made of an alloy of platinum with 10 percent iridium, to within 0.0001, that was to be measured at the melting point of ice. In 1927, the meter was more precisely defined as the distance, at 0°, between the axes of the two central lines marked on the bar of platinum-iridium kept at the BIPM, and declared Prototype of the meter by the 1st CGPM, this bar being subject to standard atmospheric pressure and supported on two cylinders of at least one centimeter diameter, symmetrically placed in the same horizontal plane at a distance of 571 mm from each other.

The 1889 definition of the meter, based upon the artifact international prototype of platinum-iridium, was replaced by the CGPM in 1960 using a definition based upon a wavelength of krypton-86 radiation. This definition was adopted in order to reduce the uncertainty with which the meter may be realized. In turn, to further reduce the uncertainty, in 1983 the CGPM replaced this latter definition by the following definition:

The meter is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second.

Note that the effect of this definition is to fix the speed of light in vacuum at exactly 299 792 458 $m \cdot s^{-1}$. The original international prototype of the meter, which was sanctioned by the 1st CGPM in 1889, is still kept at the BIPM under the conditions specified in 1889.

Second

Unit of time (second)

Abbreviations: CGPM, CIPM, BIPM

The unit of time, the second, was defined originally as the fraction 1/86 400 of the mean solar day. The exact definition of "mean solar day" was left to astronomical theories. However, measurement showed that irregularities in the rotation of the Earth could not be taken into account by the theory and have the effect that this definition does not allow the required accuracy to be achieved. In order to define the unit of time more precisely, the 11th CGPM (1960) adopted a definition given by the International Astronomical Union which was based on the tropical year. Experimental work had, however, already shown that an atomic standard of time-interval, based on a transition between two energy levels of an atom or a molecule, could be realized and reproduced much more precisely. Considering that a very precise definition of the unit of time is indispensable for the International System, the 13th CGPM (1967) decided to replace the definition of the second by the following (affirmed by the CIPM in 1997 that this definition refers to a cesium atom in its ground state at a temperature of 0 K):

The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium 133 atom.

Kilogram

Unit of mass (kilogram)

Abbreviations: CGPM, CIPM, BIPM

At the end of the 18th century, a kilogram was the mass of a cubic decimeter of water. In 1889, the 1st CGPM sanctioned the international prototype of the kilogram, made of platinum-iridium, and declared: *This prototype shall henceforth be considered to be the unit of mass*. The picture at the right shows the platinum-iridium international prototype, as kept at the International Bureau of Weights and Measures under conditions specified by the 1st CGPM in 1889.

The 3d CGPM (1901), in a declaration intended to end the ambiguity in popular usage concerning the word "weight," confirmed that:

The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram.

Kelvin

Unit of thermodynamic temperature (kelvin)

Abbreviations: CGPM, CIPM, BIPM

The definition of the unit of thermodynamic temperature was given in substance by the 10th CGPM (1954) which selected the triple point of water as the fundamental fixed point and assigned to it the temperature 273.16 K, so defining the unit. The 13th CGPM (1967) adopted the name *kelvin* (symbol K) instead of "degree Kelvin" (symbol °K) and defined the unit of thermodynamic temperature as follows:

The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.

Because of the way temperature scales used to be defined, it remains common practice to express thermodynamic temperature, symbol T, in terms of its difference from the reference temperature T_0 = 273.15 K, the ice point. This temperature difference is called a Celsius temperature, symbol t, and is defined by the quantity equation

$$t = T - T_0.$$

The unit of Celsius temperature is the degree Celsius, symbol °C, which is by definition equal in magnitude to the kelvin. A difference or interval of temperature may be expressed in kelvins or in degrees Celsius (13th CGPM, 1967). The numerical value of a Celsius temperature t expressed in degrees Celsius is given by

$$t/°\mathrm{C} = T/\mathrm{K} - 273.15.$$

The kelvin and the degree Celsius are also the units of the International Temperature Scale of 1990 (ITS-90) adopted by the CIPM in 1989.

Tab. 1.2 Basis-Größen und -Einheiten einiger Einheiten-Systeme

Einheiten-System	Mechanik				Elektrizitätslehre	Thermodynamik		Photometrie
	Länge	Masse	Kraft	Zeit	Stromstärke	Temperatur	Stoffmenge	Lichtstärke
CGS	Zentimeter cm	Gramm g		Sekunde s				
MKSA	Meter m	Kilogramm kg		Sekunde s	Ampere A			
Technisches	Meter m		Kilopond kp	Sekunde s				
Angelsächsisches	foot ft	pound lb		second s		Fahrenheit °F		
Natürliches	Protonen-Compton-Wellenlänge l_p	Protonenmasse m_p		$t = l_p/c$ (c = Lichtgeschwindigkeit)				
Internationales (SI)	Meter m	Kilogramm kg		Sekunde s	Ampere A	Kelvin K	Mol mol	Candela cd

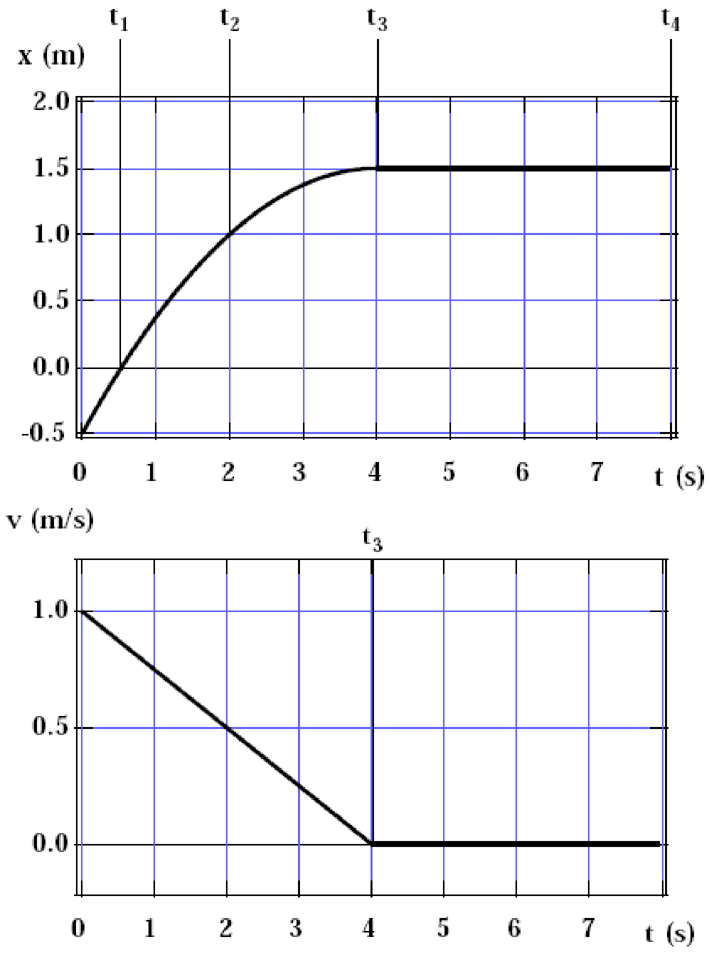
Prefixes

Tab. 1.3 Dezimale Vielfache und Teile von Einheiten

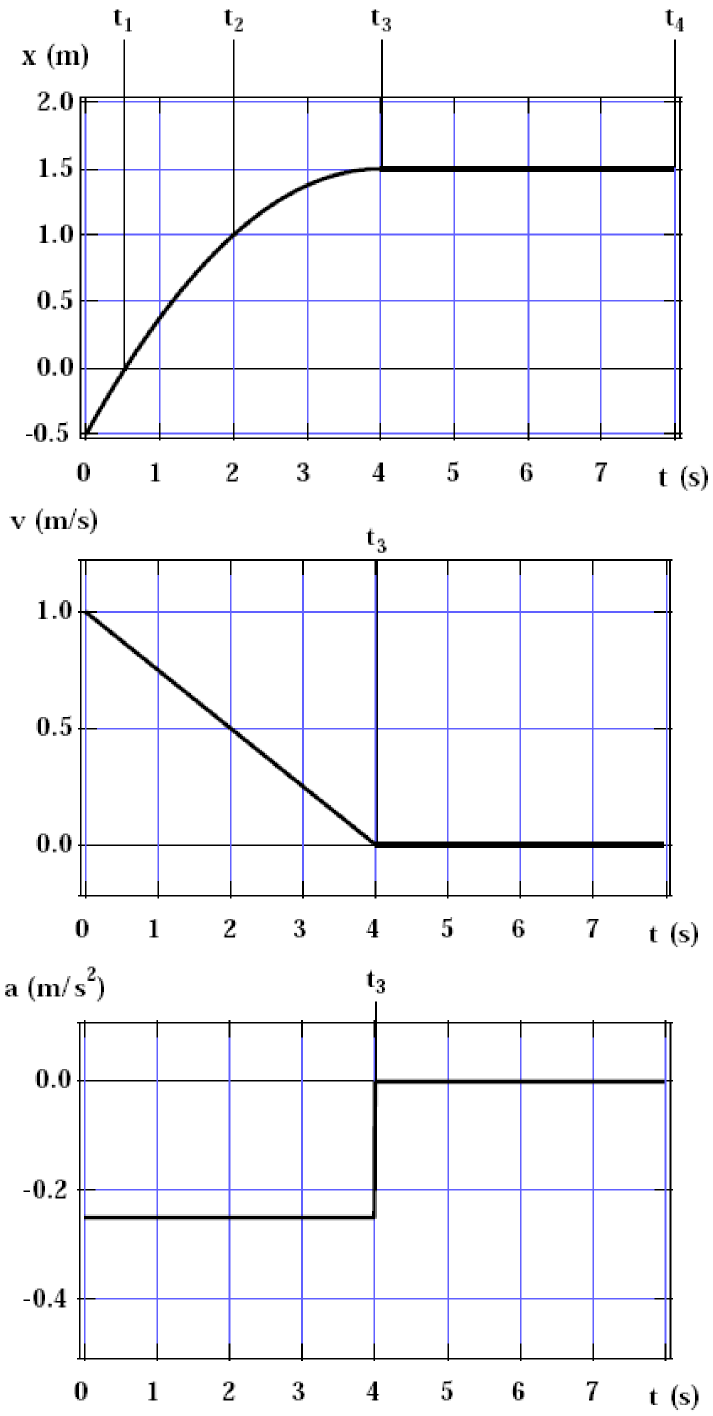
	Zehnerpotenzen	Vorsatz	Vorsatzzeichen
Vielfache:	10^{24}	Yotta	Y
	10^{21}	Zetta	Z
	10^{18}	Exa	E
	10^{15}	Peta	P
	10^{12}	Tera	T
	10^{9}	Giga	G
	10^{6}	Mega	M
	10^{3}	Kilo	k
	10^{2}	Hekto	h
	10^{1}	Deka	da
Teile:	10^{-1}	Dezi	d
	10^{-2}	Zenti	c
	10^{-3}	Milli	m
	10^{-6}	Mikro	μ
	10^{-9}	Nano	n
	10^{-12}	Pico	p
	10^{-15}	Femto	f
	10^{-18}	Atto	a
	10^{-21}	Zepto	z
	10^{-24}	Yokto	y

Table 1-3 The Universe by Orders of Magnitude

Size or Distance	(m)	Mass	(kg)	Time Interval	(s)
Proton	10^{-15}	Electron	10^{-30}	Time for light to cross nucleus	10^{-23}
Atom	10^{-10}	Proton	10^{-27}	Period of visible light radiation	10^{-15}
Virus	10^{-7}	Amino acid	10^{-25}	Period of microwaves	10^{-10}
Giant amoeba	10^{-4}	Hemoglobin	10^{-22}	Half-life of muon	10^{-6}
Walnut	10^{-2}	Flu virus	10^{-19}	Period of highest audible sound	10^{-4}
Human being	10^{0}	Giant amoeba	10^{-8}	Period of human heartbeat	10^{0}
Highest mountain	10^{4}	Raindrop	10^{-6}	Half-life of free neutron	10^{3}
Earth	10^{7}	Ant	10^{-4}	Period of Earth's rotation	10^{3}
Sun	10^{9}	Human being	10^{2}	Period of Earth's revolution around the Sun	10^{7}
Distance from Earth to the Sun	10^{11}	Saturn V rocket	10^{6}	Lifetime of human being	10^{9}
Solar system	10^{13}	Pyramid	10^{10}	Half-life of plutonium-239	10^{12}
Distance to nearest star	10^{16}	Earth	10^{24}	Lifetime of mountain range	10^{15}
Milky Way galaxy	10^{21}	Sun	10^{30}	Age of Earth	10^{17}
Visible universe	10^{26}	Milky Way galaxy	10^{41}	Age of universe	10^{18}
		Universe	10^{52}		



t1
t2
t3
t4
x (m)
2.0
1.5
1.0
0.5
0.0
-0.5
0
1
2
3
4
5
6
7
t (s)
v (m/s)
t3
1.0
0.5
0.0
0
1
2
3
4
5
6
7
t (s)



x (m)
t_1
t_2
t_3
t_4
2.0
1.5
1.0
0.5
0.0
-0.5
0
1
2
3
4
5
6
7
t (s)
v (m/s)
1.0
0.5
0.0
t (s)
a (m/s^2)
0.0
-0.2
-0.4
t (s)