Development of Computer Generated Animations

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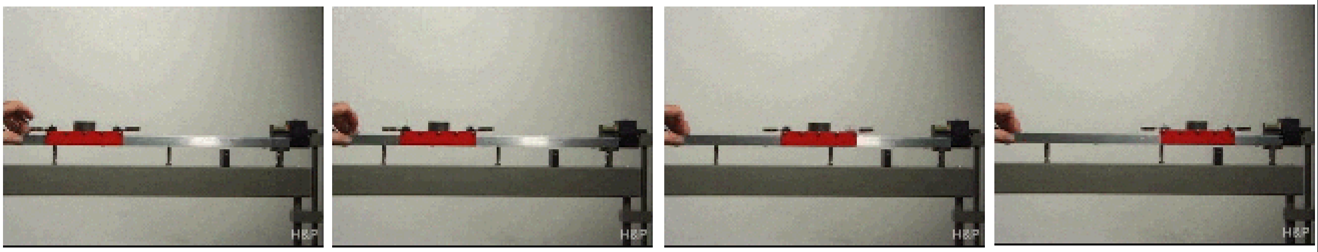
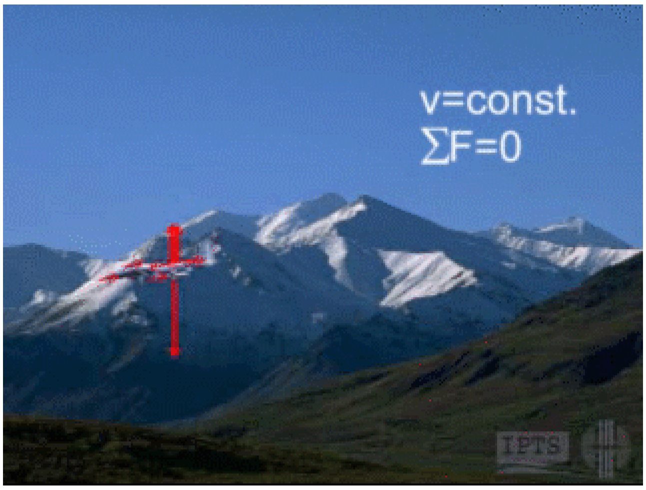
A series of short videos in mpg and wmv format about different topics of physics have been developed. The flexibility of computer graphics in form of continuous transitions, virtual trips and motivating visualizations are used to support difficult learning tasks.

1.1. Glider on an air-cushion track
Constant Velocity and Force



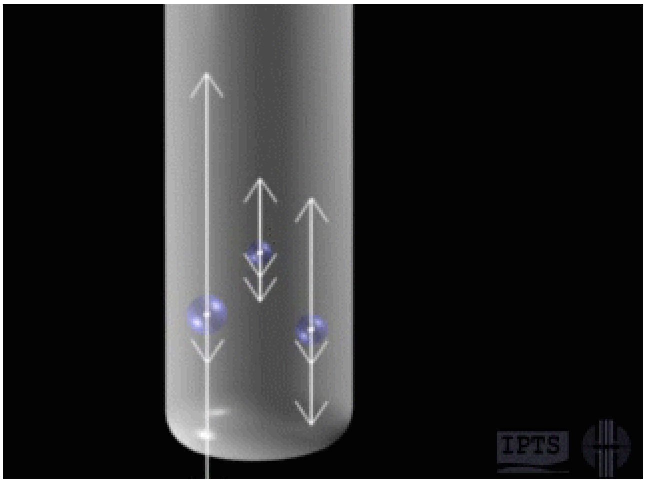
A far spread misconception relates a constant velocity with a constant driving force. The video shows the classical experiment of a glider on an air-cushion track to demonstrate the physics of a movement with constant velocity. However, many evaluation studies have shown, that this misconception about a constant velocity and a constant driving force is a very robust one. We permanently experience in our daily life that it needs a force to move things around and this experience seems to neutralize the results of physics teaching.
As an addition to the classical air-cushion experiment it may be helpful to confront students with the physics interpretation of scenes from daily life, where objects move with constant velocity. The following 7 videos show such scenes. When shown and discussed with students (possibly more than ones) a conceptual change towards a Newtonian interpretation may be supported.
air_cushion_2air_cushion_track.mpg (10 MB)
air_cushion_2air_cushion_track.wmv(0,7 MB) (lower resolution)

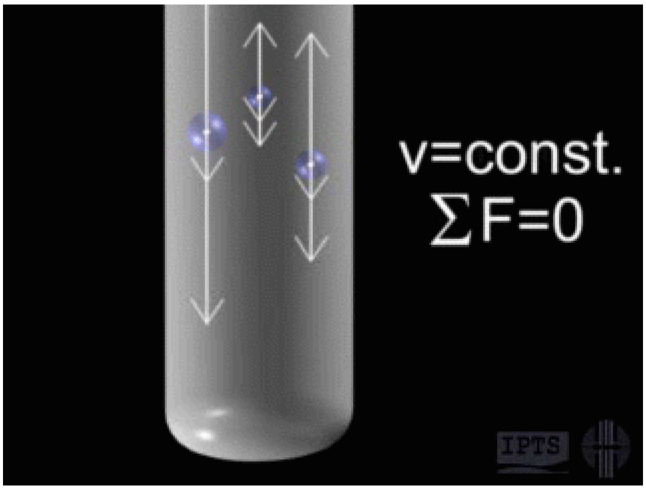
1.2. Gliding Aeroplane
Constant Velocity and Force



Comments see „Glider on an air-cushion track“ above.
gliding aeroplane.mpg (8 MB)
gliding aeroplanes.wmv(0,6 MB) (lower resolution)

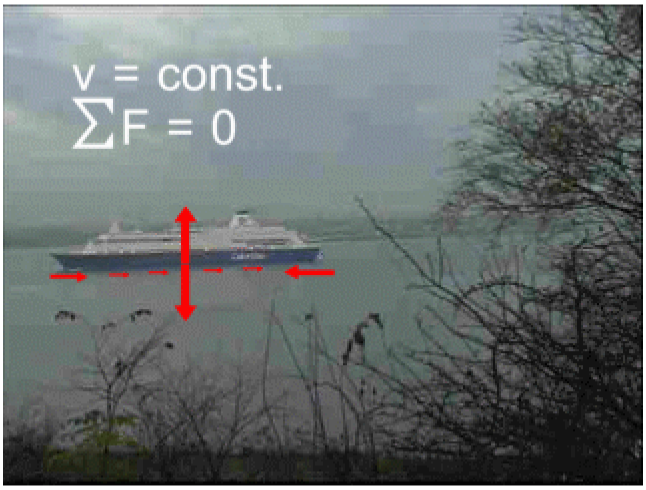
1.3. Raising Bubbles
Constant Velocity and Force





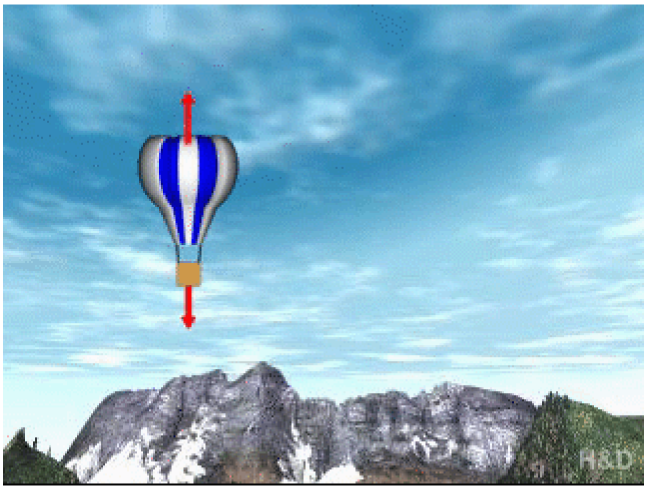
Comments see „Glider on an air-cushion track“ above.
raising_bubbles.mpg (9 MB)
raising_bubbles.wmv(0,7 MB) (lower resolution)

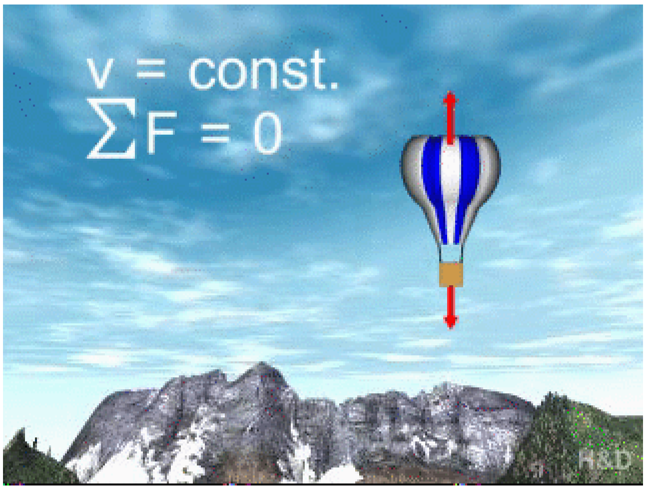
1.4. Ship Entering a Harbour
Constant Velocity and Force



Comments see „Glider on an air-cushion track“ above.
ship.mpg (5 MB)
ship.wmv(0,3 MB) (lower resolution)

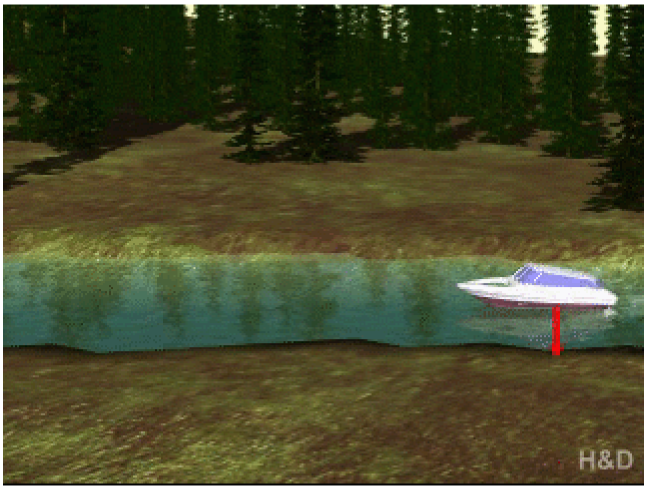
1.5. Drifting Balloon
Constant Velocity and Force

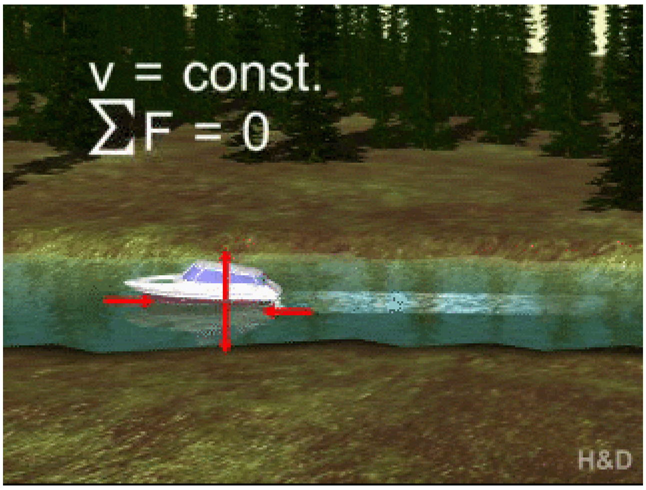




Comments see „Glider on an air-cushion track“ above.
balloon.mpg (5 MB)
balloon.wmv(0,4 MB) (lower resolution)

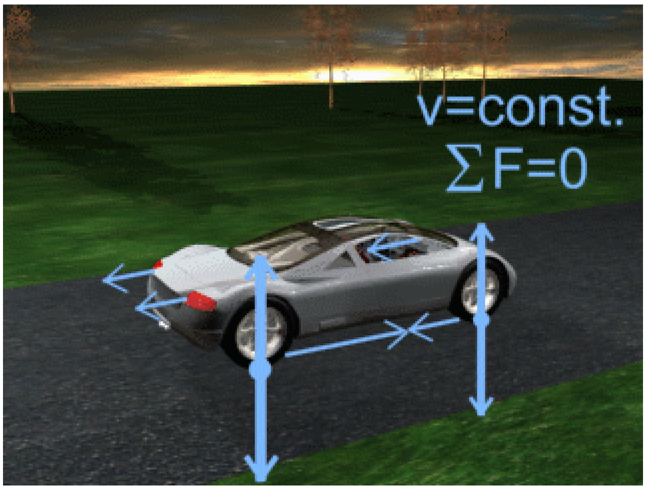
1.6. Motor Boat on a River
Constant Velocity and Force





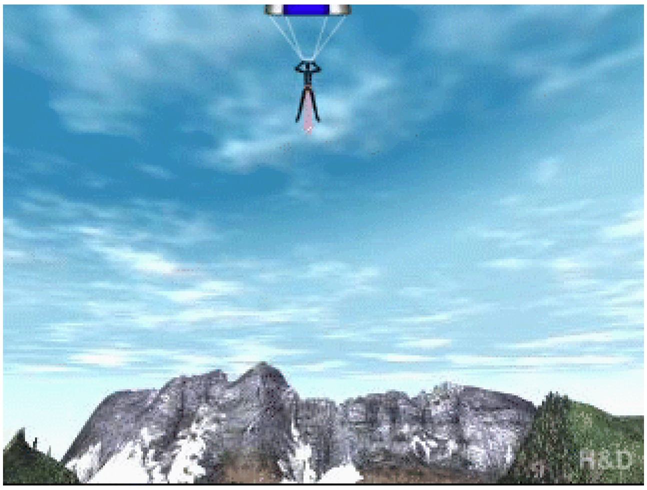
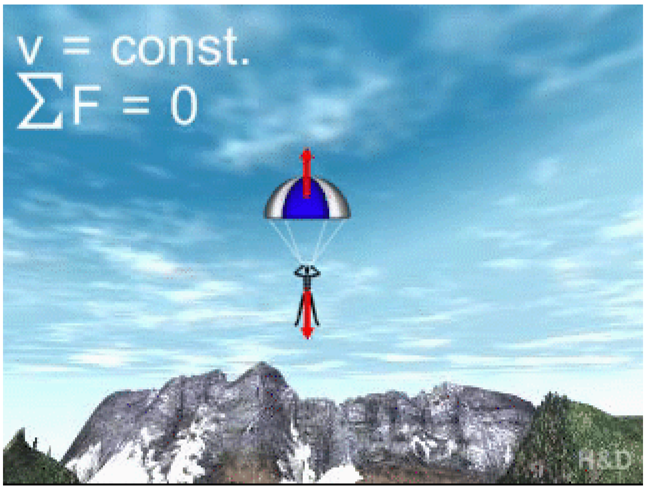
Comments see „Glider on an air-cushion track“ above.
motor_boat.mpg (5 MB)
motor_boat.wmv(0,3 MB) (lower resolution)

1.7. Driving Vehicle
Constant Velocity and Force

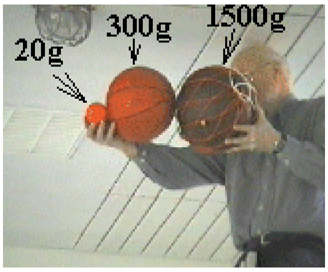


Comments see „Glider on an air-cushion track“ above.
driving_vehicle.mpg (9 MB)
driving_vehicle.wmv(0,7 MB) (lower resolution)

1.8. Skydiver, Gliding Downwards
Constant Velocity and Force

<table>
<tr><td>
</td><td>
</td></tr>
<tr><td colspan="2">Comments see „Glider on an air-cushion track“ above.
skydiver.mpg (5 MB)
skydiver.wmv(0,4 MB) (lower resolution)</td></tr>
</table>

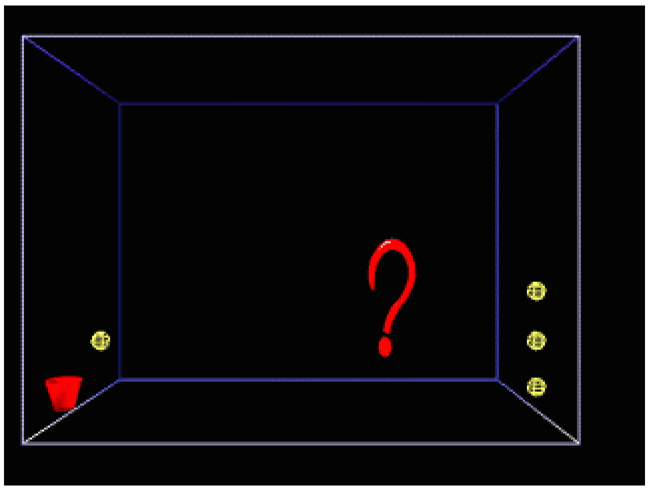
2.1 Objects in Free Fall
Inertial Mass and Gravitational Mass





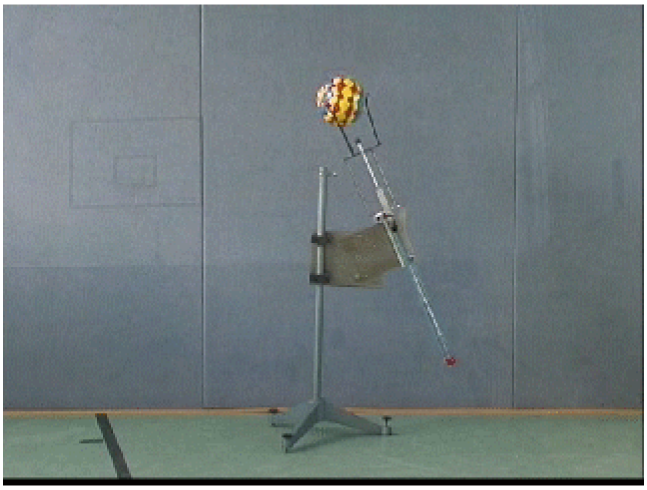
Accelerated movements of objects under the influence of gravity are a major part of every course in mechanics. To support the related classroom experiments, videos from experiments, carried out on a larger scale, may be helpful. In addition the relation between experiment and some corresponding simulations can be emphasized
free_fallfree_fall.mpg (5 MB)
free_fallfree_fall.wmv(0,6 MB) (lower resolution)

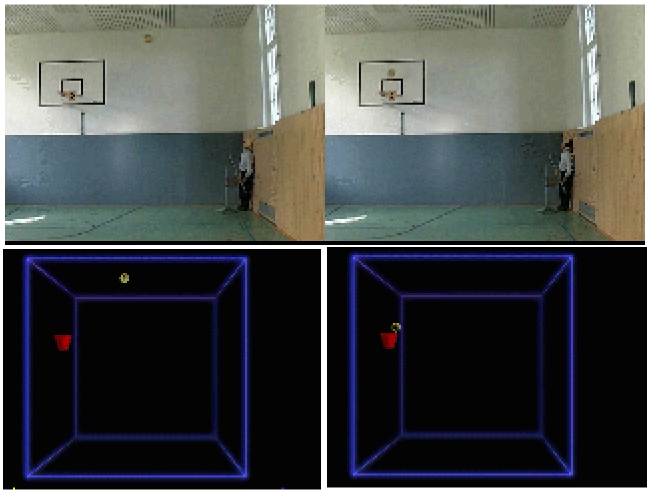
2.2. Horizontal Throw
Relation between Experiment and Simulation

The video shows the experiment of a horizontal throw and focuses on the principle of superposition. The question is posed:
If an object starts to fall at the same moment in time as the ball in the video, will it reach the floor before or later or at the same moment in time?
A first answer can be found by using an appropriate simulation.<p>
horizontal throw.mpg (10 MB)
horizontal throw.wmv(0,5 MB) (lower resolution)

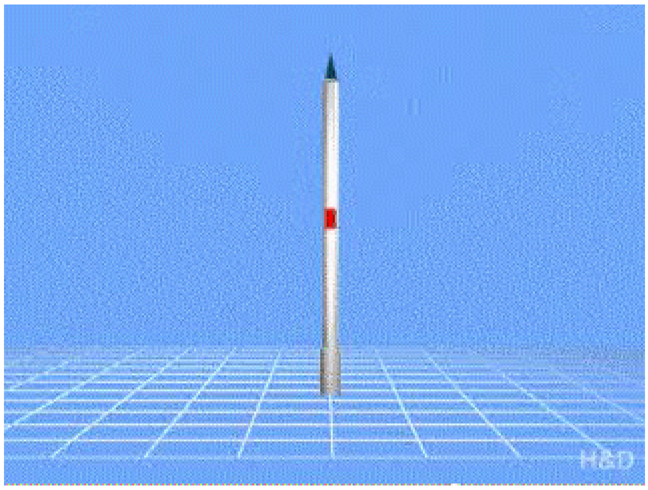
2.3. Inclined Throw
Relation between Experiment and Simulation





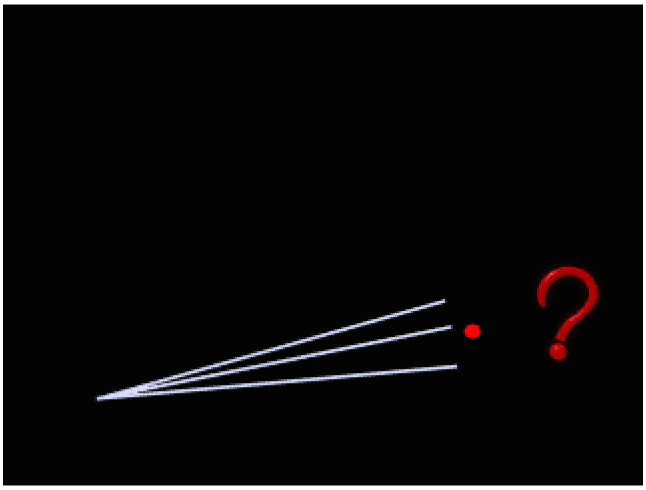
The inclined rod, driven by a spring, hits the ball and makes a point. This video can serve as a motivational entrance to use theory a possibly a simulation and to solve related assignments.
inclined_throw.mpg (12 MB)
inclined_throw.wmv(0,7 MB) (lower resolution)

2.4. Vertical Throw
Free of Force or Free of Weight



The video shows a drop tower, located at Bremen, Germany, where low-cost experiments under conditions of weightlessness are carried out. In the animation the focus is set on the difference between weightlessness and „being free of force“.
drop_tower.mpg (11 MB)
drop_tower.wmv(1,3 MB) (lower resolution)

2.5. Long Stick and a Ball Dropping Down
Which One is First

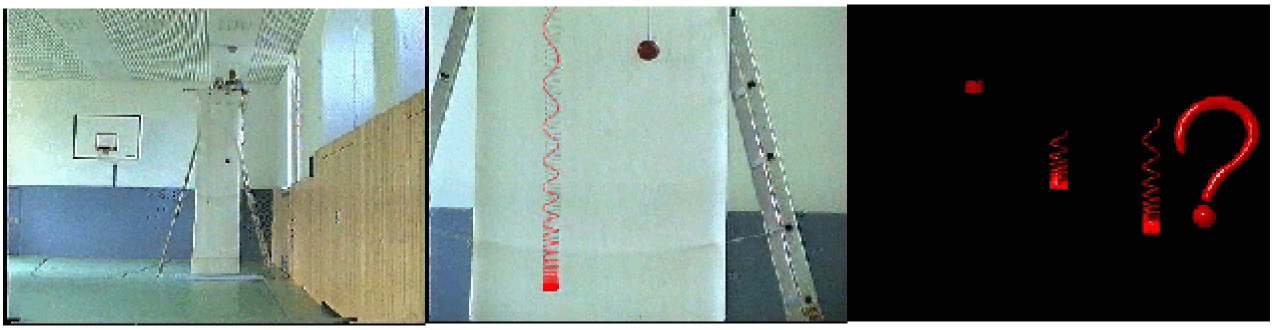


The long stick and the ball are released at the same moment in time. Which one will hit the floor first?
falling_stick_1.mpg (10 MB)
falling_stick_1.wmv(0,7 MB) (lower resolution)

2.6. Long Stick and a Ball Dropping Down
The Experiment

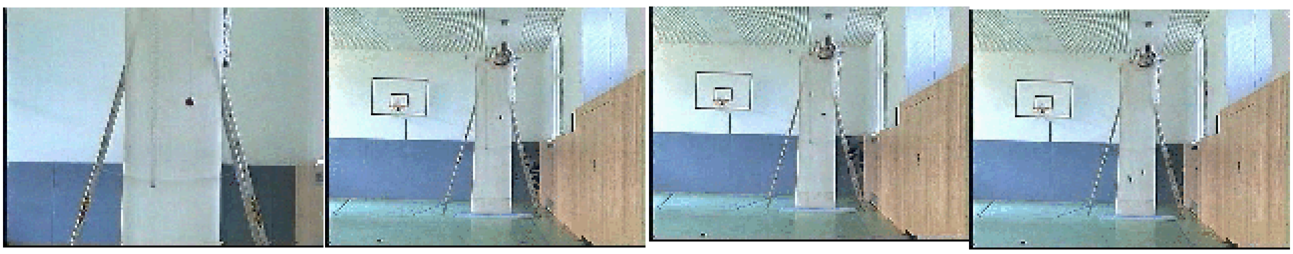
This video shows the experiment, where the long stick and the ball are released at the same moment in time and the stick hits the floor, when the ball is still half a meter in the air.
What about the rule that all objects experience the same acceleration in free fall?
falling_stick_2.mpg (13 MB)
falling_stick_2.wmv(0,8 MB) (lower resolution)

2.7. A Slinky Starts Falling
But How?



The question, focused on in this video, is about the movement of the lower end of a hanging soft spring - a Slinky. When the spring is released, will the lower end go up, stay at the same place or go down?
slinky_1.mpg (14 MB)
slinky_1.wmv(0,7 MB) (lower resolution)

2.8. A Slinky in Free Fall
The Experiment

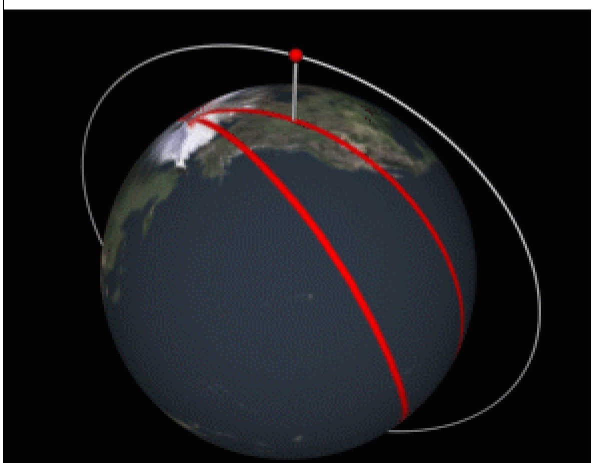


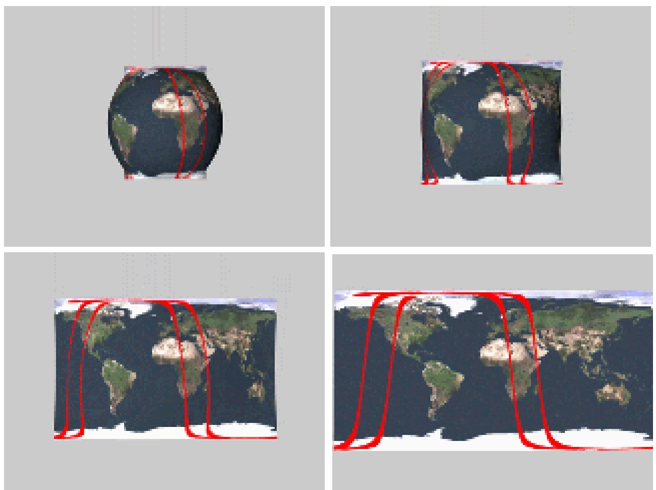
This video shows the experiment, where a soft spring, hanging down and a ball, placed at the same height as the centre of mass of the spring, are released at the same moment in time. This experiment can stimulate a discussion about the limits of the models of mass points and rigid bodies.
slinky_2.mpg (11 MB)
slinky_2.wmv(0,8 MB) (lower resolution)

3.1. Circular Motion and Force
A Question

At the beginning an experiment is shown where a sphere spins upward in a beaker. Shifting over to a computer generated animation the focus is set on the question of the direction of the centripetal force.
rotation_and_force.mpg (7 MB)
rotation_and_force.wmv(0,9 MB) (lower resolution)

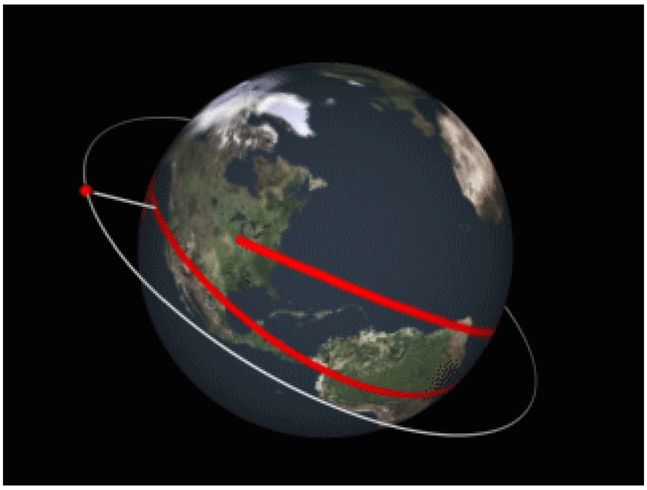
3.2. Orbit of a Satellite, Crossing the Poles
in 3D and 2D

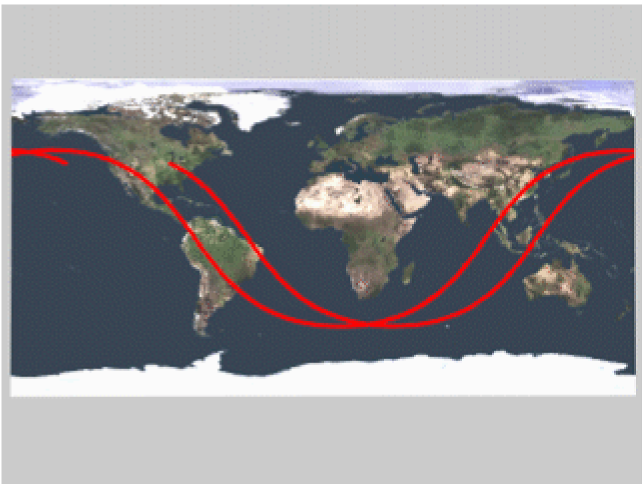




This video and the following 4 owns deal with the modern topic of satellites and the well known didactic problem of restricted spatial imagery among our students.
The video shows the projection of the orbit of a polar satellite on the surface of the earth, and then a smooth transition from this quite obvious picture to the less obvious presentation on a 2-dimensional world map.
polare_satellite.mpg (10 MB)
polare_satellite.wmv(1,1 MB) (lower resolution)

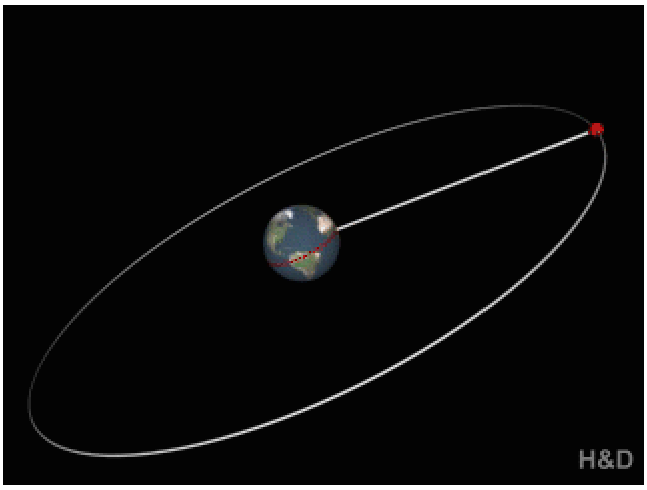
3.3. Orbit of a Non-Polar Satellite in 3D and 2D

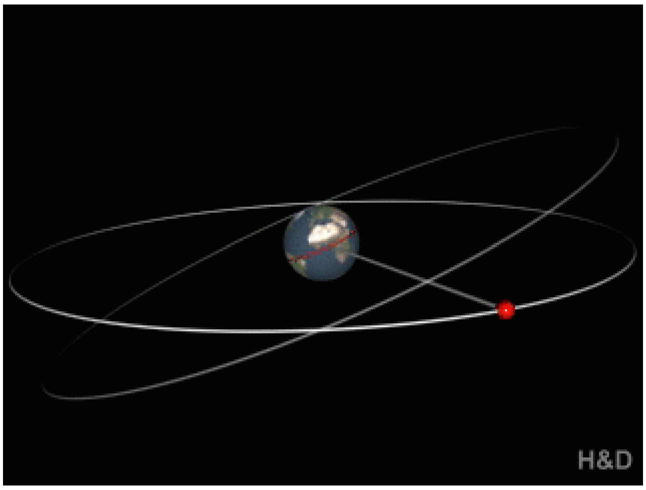




The video shows the projection of the orbit of a non-polar satellite on the surface of the earth, and then a smooth transition from this quite obvious picture to the less obvious presentation on a 2-dimensional world map.
non-polare_satellite.mpg (9 MB)
non-polare_satellite.wmv(1,1 MB) (lower resolution)

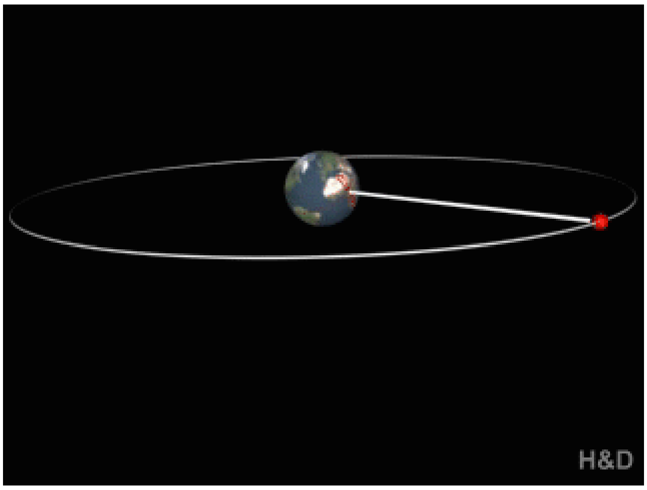
3.4.1. Geo-stationary Satellite And a Question about a Deviated Orbit

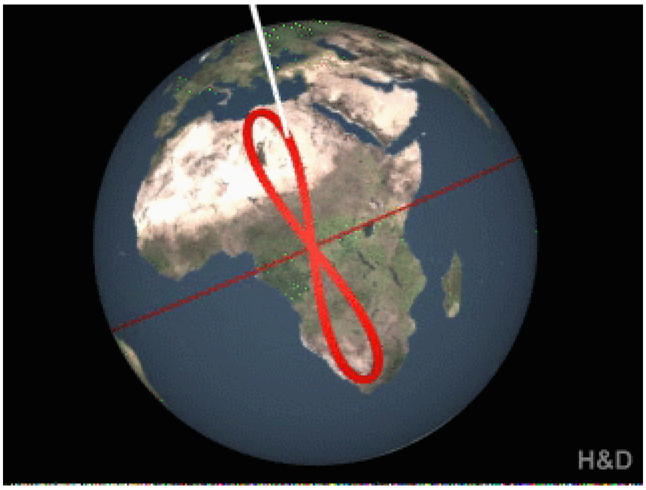




This video points out the conditions for a satellite to be geo-stationary and focuses on the question about the projection of a satellite which moves on a slightly deviated orbit. Experience has shown that this question is too difficult for most of our students and proves again that our spatial imagery is rather restricted, especially if we have to deal with moving objects.
geostationary_satellite.mpg (9 MB)
geostationary_satellite.wmv(0,7 MB) (lower resolution)

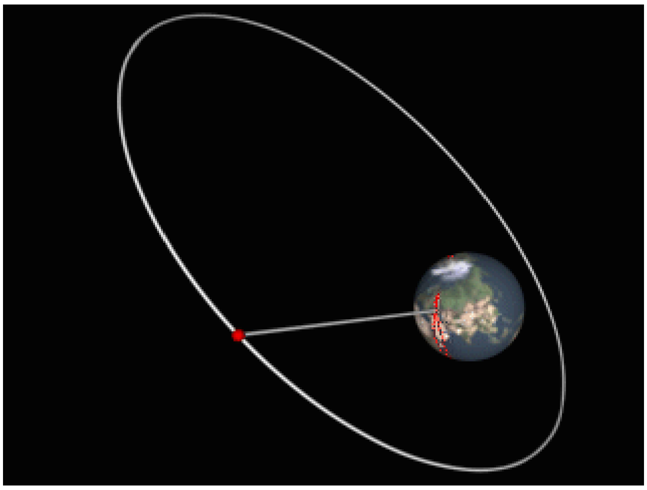
3.4.2. Geo-stationary Satellite on a Deviated Orbit

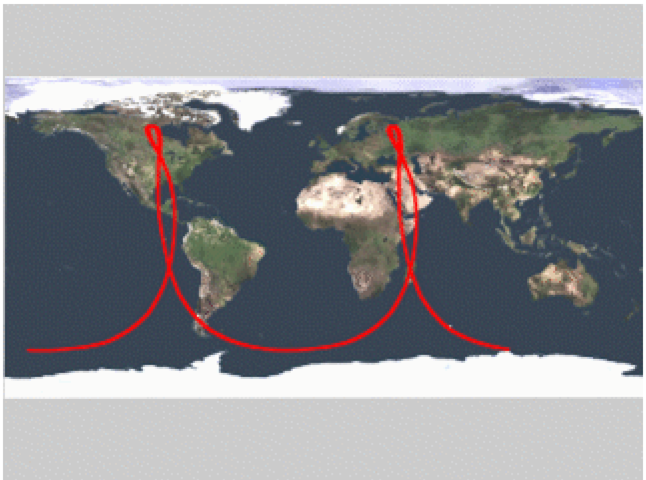




The orbit of a geo-stationary satellite, moving on a deviated orbit, is projected on the surface of the earth. As a training of spatial imagery it may be useful to let students prove that the video shows a correct result.
non-geostationary_satellite.mpg (10 MB)
non-geostationary_satellite.wmv(0,9 MB) (lower resolution)

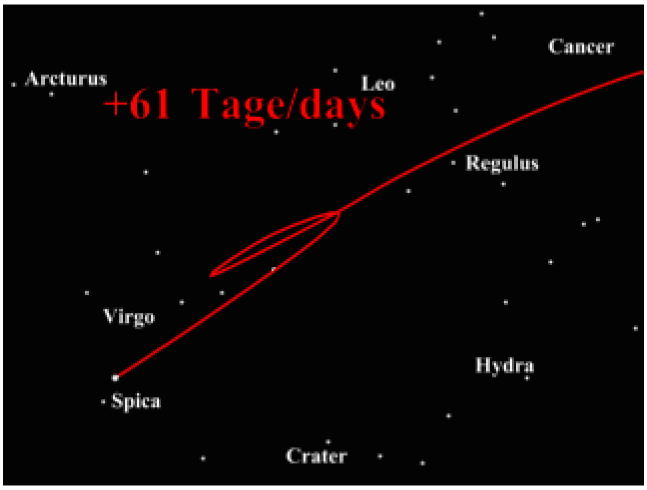
3.5. Orbit of a Molnya Satellite in 3D and 2D

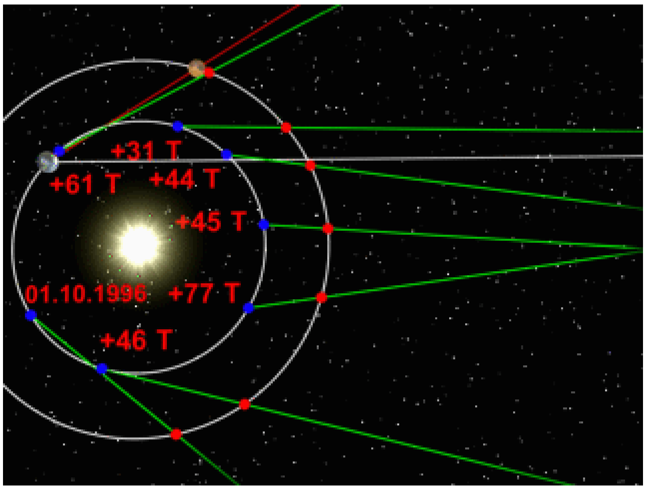




On the upper northern hemisphere the normal geo-stationary satellites are not visible. The video shows how the orbits of the so-called Molnya satellites have been selected to serve over part of there orbit as nearly gestational.
molnya_satellite.mpg (18 MB)
molnya_satellite.wmv(1,4 MB) (lower resolution)

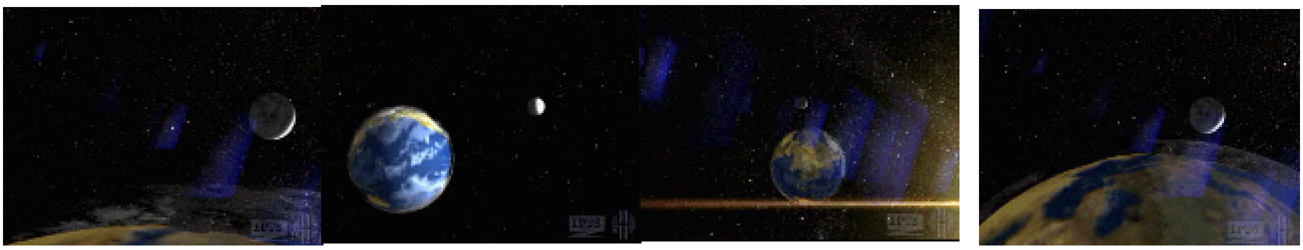
4.1. Movement of Planet Mars
Geocentric versus Heliocentric Perspective





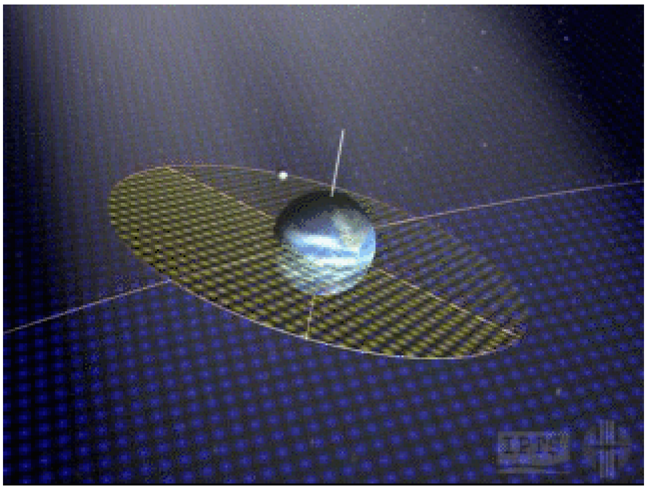
To understand the retrogradation of our planets, the geocentric and the heliocentric perspective have to be unified in thought. To support this mental task, the video shows the pictures from these two perspectives with smooth transitions.
orbit_of_planet_mars.mpg (26 MB)
orbit_of_planet_mars.wmv(2,3 MB) (lower resolution)

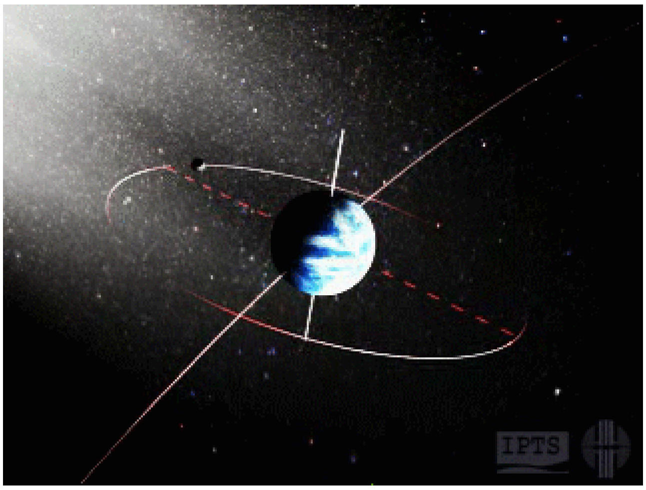
4.2. Phases of the Moon



To explain the regular phenomenon of the phases of the moon, two perspectives - one from the earth and one from outside the earth and moon, have to be kept active in thought. This seems to be a mental challenge for many students. The video supports this mental task. In a virtual trip, starting from the earth, circulating around earth and moon and ending again on the earth, these two perspectives are brought rather closely together.
phases_of_the_moon.mpg (11 MB)
phases_of_the_moon.wmv(1,1 MB) (lower resolution)

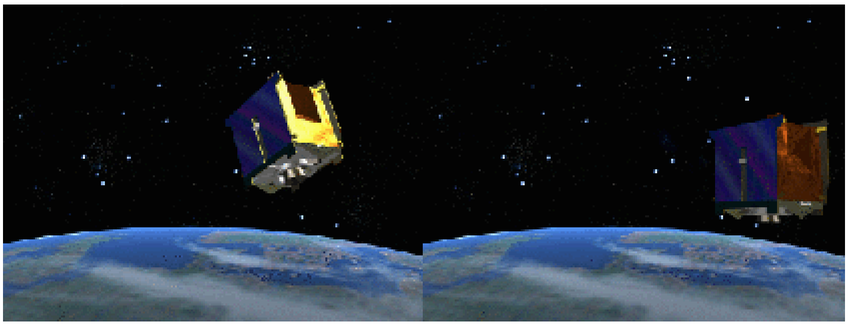
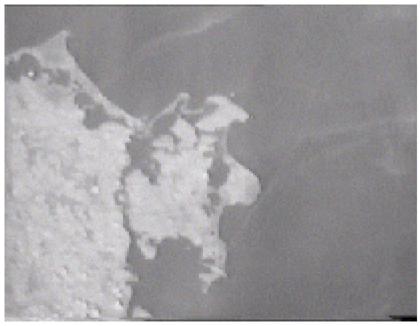
4.3. Eclipse of the Moon





To explain the irregular phenomenon of the eclipse of the moon is not straightforward. It has to be kept in mind that there is an angle between the ecliptic and the plane, in which the moon circulates around the earth. Only if the shadow of the earth and the moon coincide on the cutting line of these tow planes, an eclipse occurs. The video tries to support this explanation.
eclipse_of_the_moon.mpg (14 MB)
eclipse_of_the_moon.wmv(1,2 MB) (lower resolution)

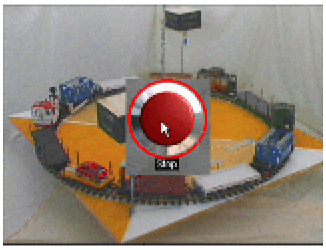
5.1. Conservation of Angular Momentum (How to Rotate a Satellite)

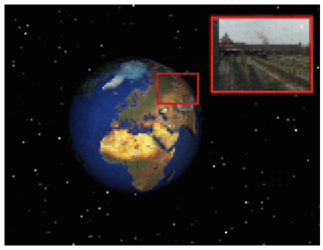



Smaller satellites can be changed in their position by controlling internal rotors, relying on conservation of angular momentum. The video does not give any answers but is meant to be used as interesting and motivating start-up-activity for the related topic.
rotating_a_satellite.mpg (17 MB)
rotating_a_satellite.wmv(1,2 MB) (lower resolution)

5.2. Conservation of Angular Momentum (What about the Earth, when a train starts moving?)

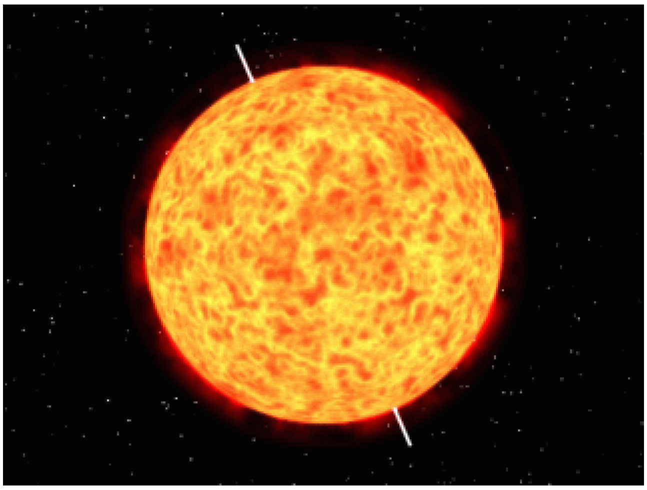
> >

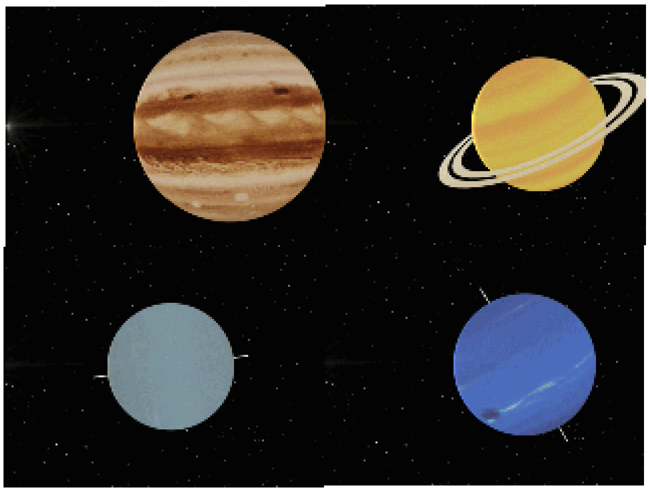



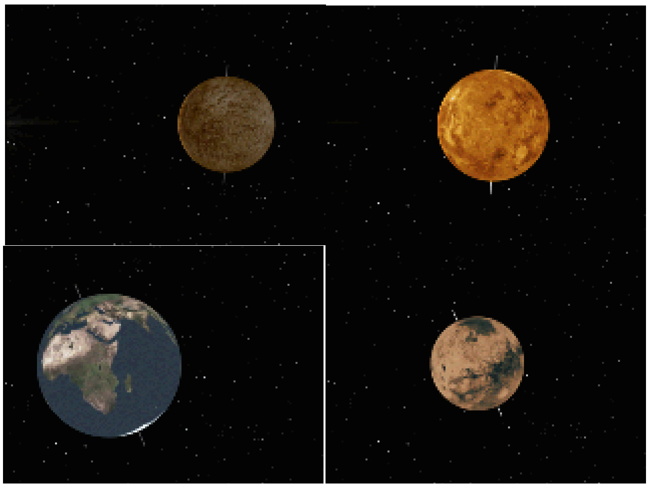


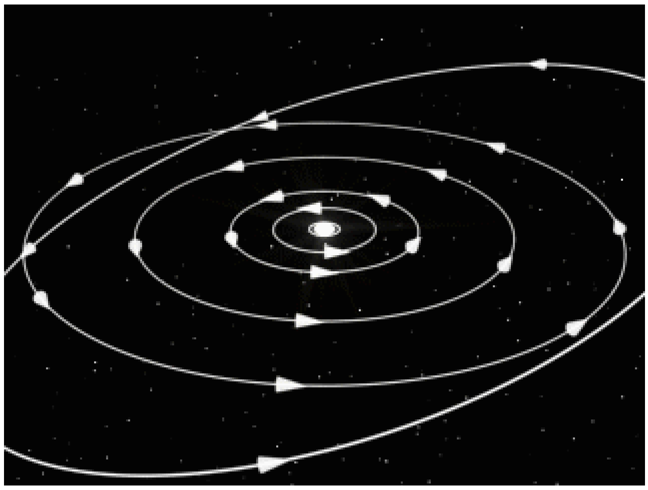
A tele-experiment has been set up, where a toy train circles on a support, with a central suspension. Controlled by an applet and observed by a WEB-cam the law of conservation of angular momentum could be demonstrated.
The video shows this experiment and shifts over to a real train, starting at a railway station and posing the question: will the earth react and if yes, how?
Again there is no answer. The video is mean to stimulate a discussion about the universal validity of conservation of angular momentum and about the earth as rigid or elastic body.
conservation_of_angular_momentum.mpg (22 MB)
conservation_of_angular_momentum.wmv(2,5 MB) (lower resolution)

5.3. The System of Planets and Angular Momentum









During a virtual trip along the sun and all the planets the focus is set on the fact that the sun and all planets (with only two exceptions) rotate around their axis and orbit around the sun in the same sense and close to a common plane.
The video is meant to stimulate a discussion about conservation of angular momentum and possible conclusions in respect to the development of our planetary system.
system_of_planets.mpg (24 MB)
system_of_planets.wmv(2,5 MB) (lower resolution)