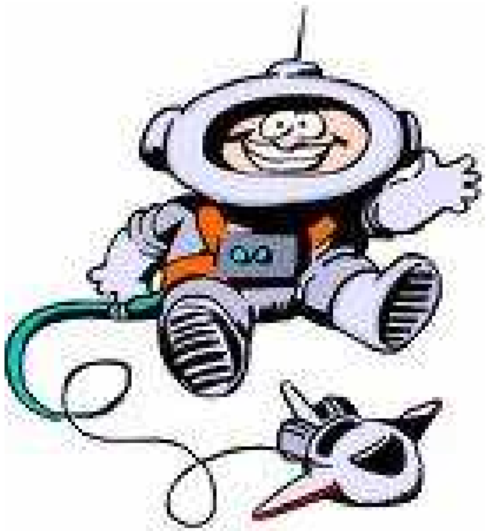
COSMOS –
Cosmic Velocities

Mag. Ronald Binder
Mag. Veronika Ruedegger

Lesson plan



[1] Galileo Navigation Satellite; Credits: ESA (http://www.esa.int/)

Guided Research Model

www. virtuelleschule.at/inlot

General Informations

Mag. Ronald Binder
Mag. Veronika Ruedegger

Duration:

6 x 50 min

Vocabulary:

Newton´s law of gravity, Cavendish constant, centripetal and centrifugal force, gravitational field, kinetic energy, gravitational potential energy

Tools and Materials:

Computer, internet, paper, pencils, work sheets

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Aims and Objectives:

Students should be able to

- understand the principle of Newton´s law of gravity and apply it correctly
- understand the relevance of the cosmic velocities
- differentiate between circular, elliptic, parabolic and hyperbolic paths of spacecrafts
- calculate the cosmic velocities from Newton´s law of gravity
- use java applets independently and understand the physics behind it

Educational Phase 1

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Mag. Veronika Ruedegger

Stimulation:
1 x 25 min

- presentation of selected photos of satellites
- short trailer about launches in Cape Canaveral
- discussion about geostationary satellites, GPS and GALILEO

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Scientific Prediction:
1 x 25 min

General discussion about

- the launch of the rockets – which velocities are necessary to move within the gravitational field of the earth (satellites)
- the launch of the rockets – which velocities are necessary to escape the gravitational field of the earth (spacecrafts)
- internet-sites which deal with cosmic velocities

Educational Phase 3

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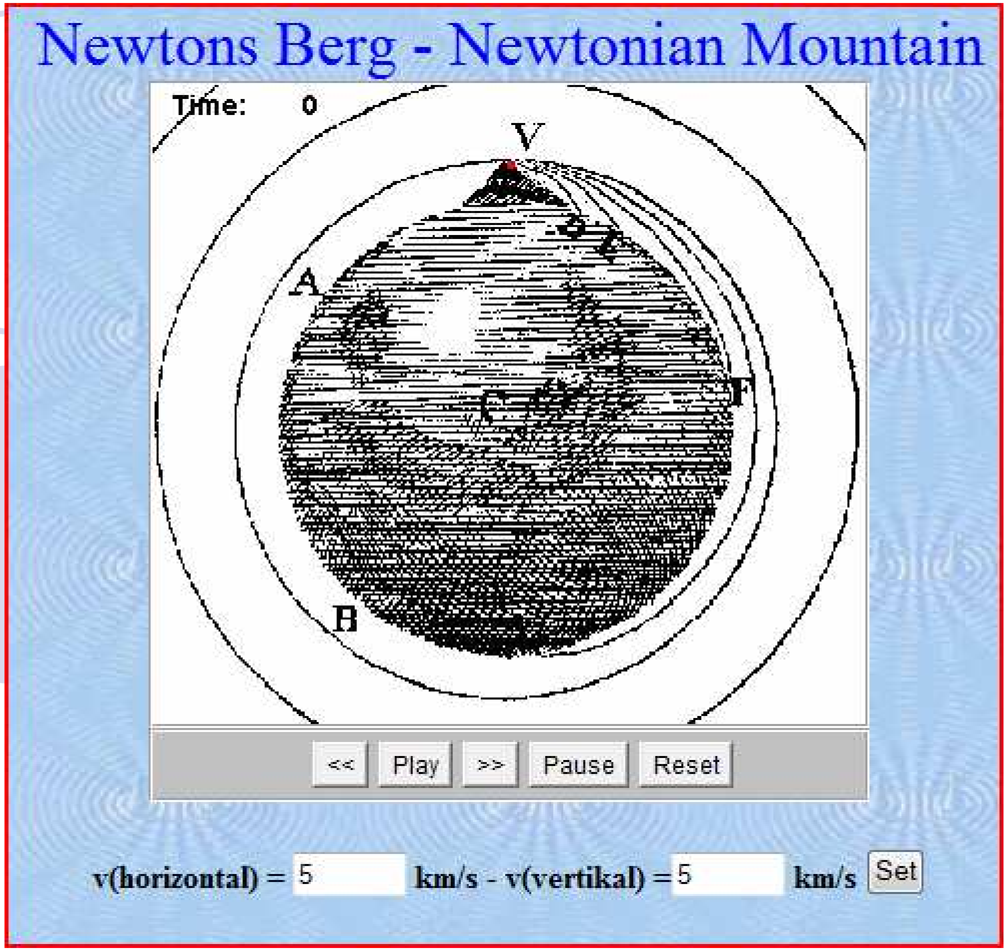
Experimental Activities 1

1 x 25 min

Run the java applet by varying the horizontal and vertical velocities



[2] Java-Applet „Newtons Berg“

http://www.schulphysik.de/java/physlet/applets/newtonberg.html

COSMOS

Educational Phase 3

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Experimental Activities 2

1 x 25 min

Simulation of Newton´s „lunar calculation“: filling in a work sheet

Der Mond als geworfener Apfel?

Newtons Mondrechnung

a_{Apfel} =

a_{Mond} =

$\frac{g}{a_{Mond}}$ = (Tipp:)

Wenn sich der Mond und ein geworfener Apfel aufgrund derselben Ursache (Beschleunigung, Kraft) bewegen, muss diese Beschleunigung proportional zu sein:

a ~

Simulation der Bahnkurve

Zeichne jeweils eine typische Bahnkurve rechts in die Skizze! Es treten folgende Bahnkurven auf:

____

____

____

Bemerkung:

____

Simulation F~1/r^x

____

____

Isaac Newton (1642 - 1727), Professor in Cambridge

[3] Work Sheet „Der Mond als geworfener Apfel?“
http://www.brichzin.de/unterricht/mondapfl/arbeitsblatt.html

Educational Phase 3

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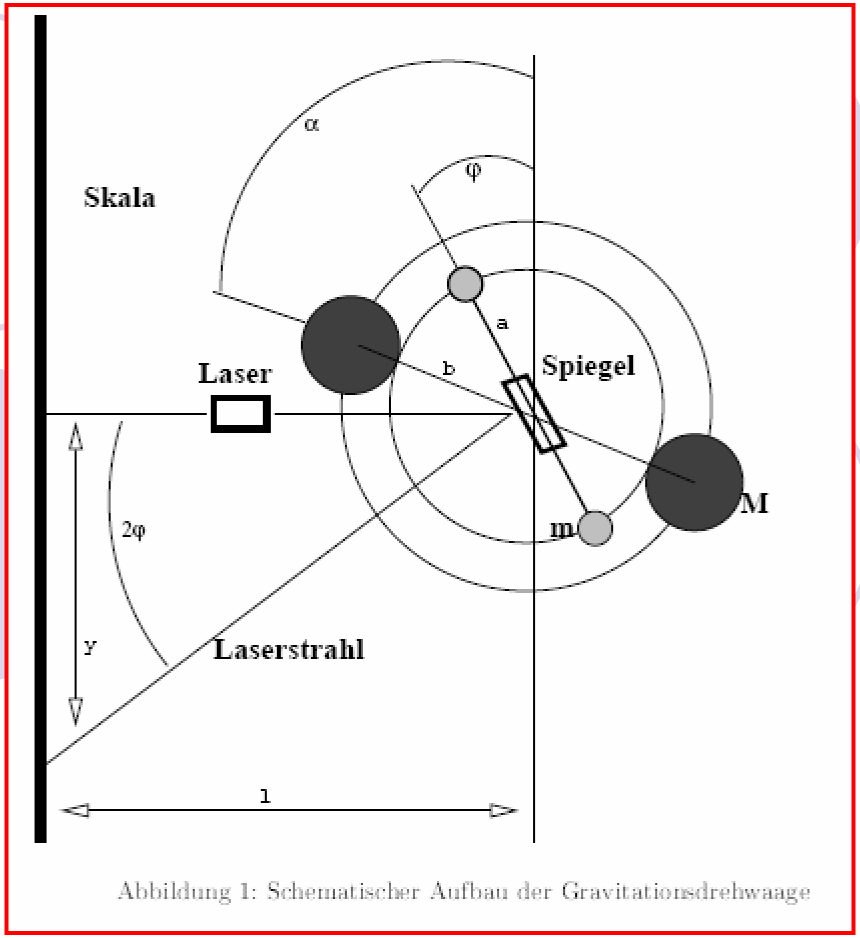
Experimental Activities 3

1 x 50 min

Calculation of the cavendish constant from an experiment



[4] Graphic from „Leybold Didaktik“

Educational Phase 4

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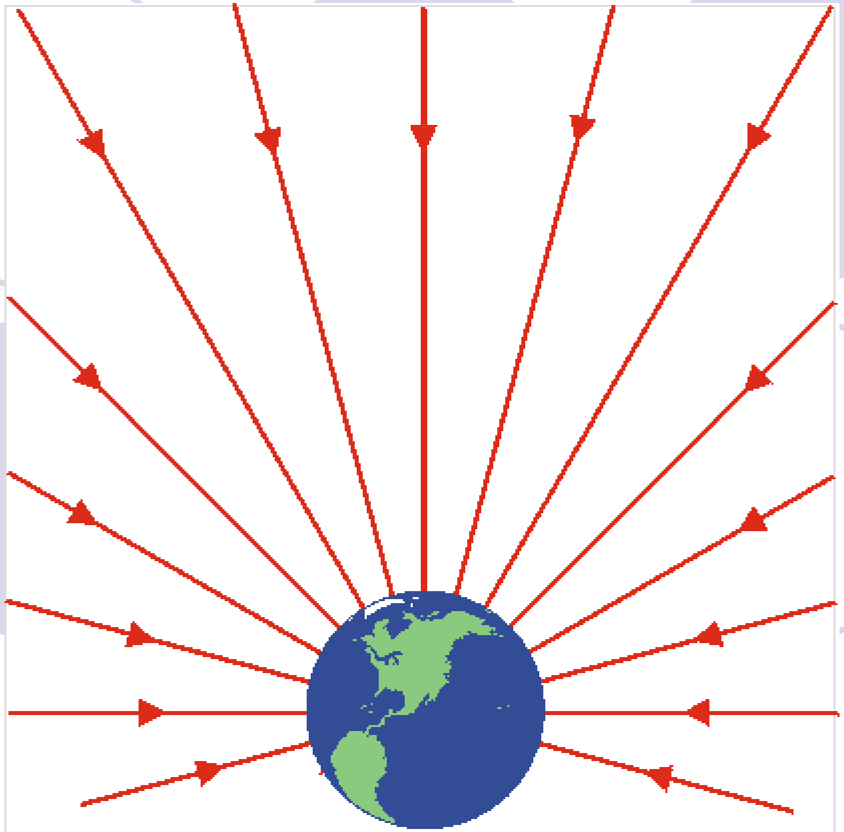
Abstraction of the findings 1:

1 x 50 min

Calculating work needed to move within the gravitational field of the earth



[5] From http://leifi.physik.uni-muenchen.de/web_ph11/umwelt-technik/10_gravfeld/index.htm

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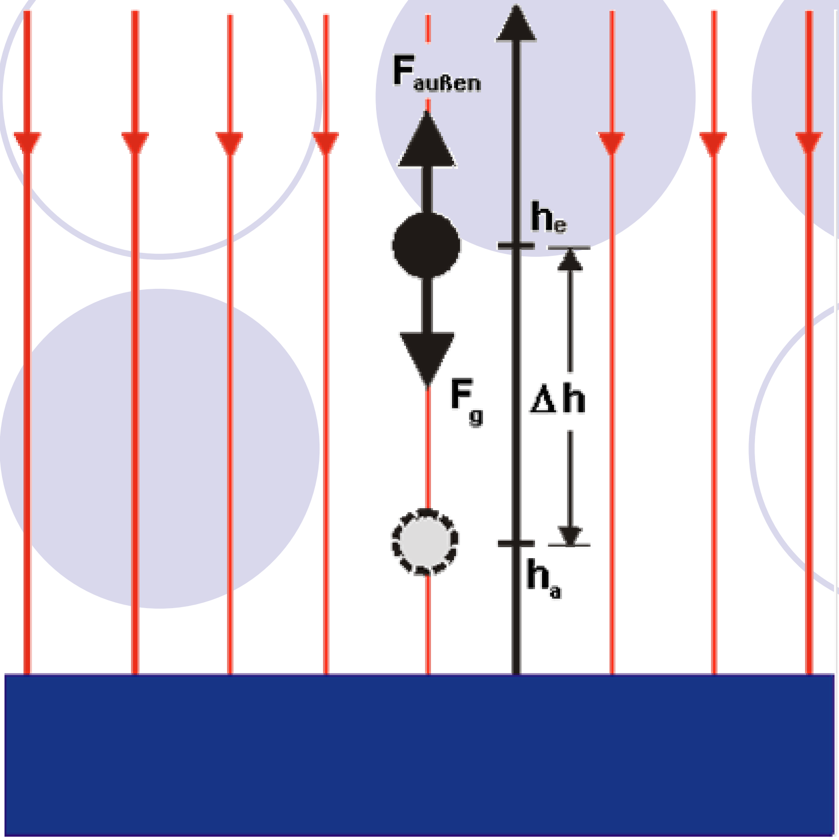
Hypothesis:

Homogeneous field



[6] From http://leifi.physik.uni-muenchen.de/web_ph11/umwelt-technik/10_gravfeld/index.htm

Educational Phase 4

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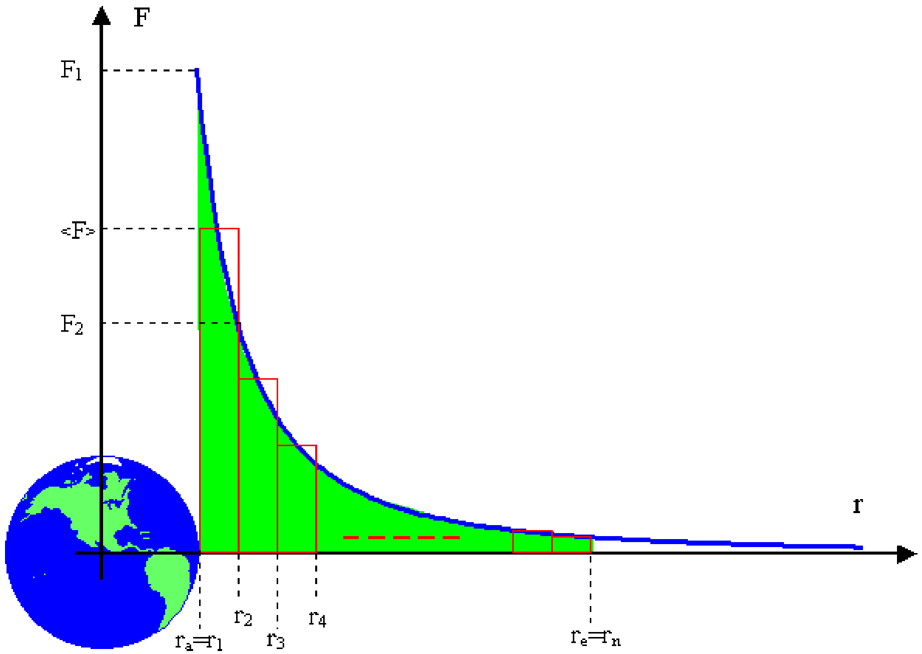
$$
\begin{aligned}
W &= \int_{r_1}^{r_2} G\frac{Mm}{r^2}\,\mathrm{d}r \\
&= GMm\int_{r_1}^{r_2} \frac{1}{r^2}\,\mathrm{d}r \\
&= GMm\int_{r_1}^{r_2} r^{-2}\,\mathrm{d}r \\
&= GMm\left(-r^{-1}\right)\Big|_{r_1}^{r_2} \\
&= GMm\left(-\frac{1}{r_2}-\left(-\frac{1}{r_1}\right)\right) \\
W &= GMm\left(\frac{1}{r_1}-\frac{1}{r_2}\right)
\end{aligned}
$$



[7] From http://leifi.physik.uni-muenchen.de/web_ph11/umwelt-technik/10_gravfeld/index.htm

Educational Phase 4

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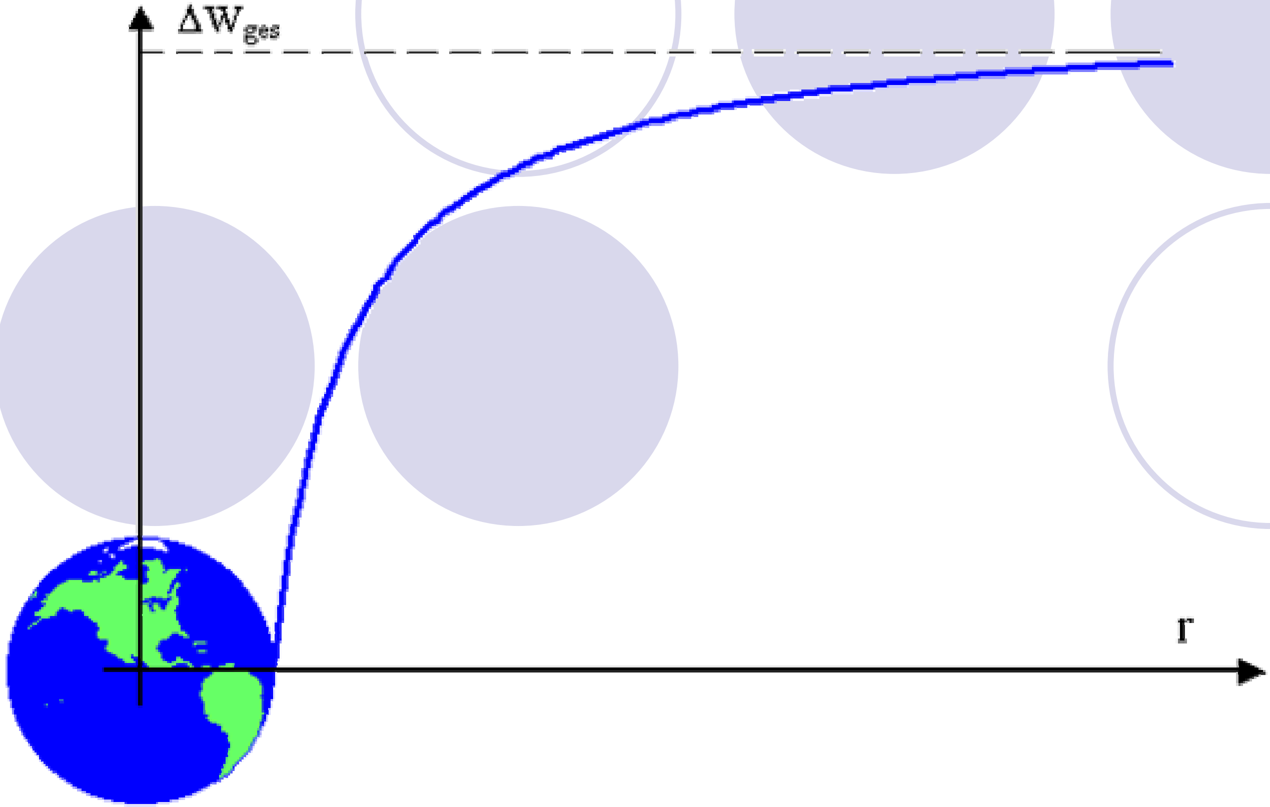

[8] From http://leifi.physik.uni-muenchen.de/web_ph11/umwelt-technik/10_gravfeld/index.htm

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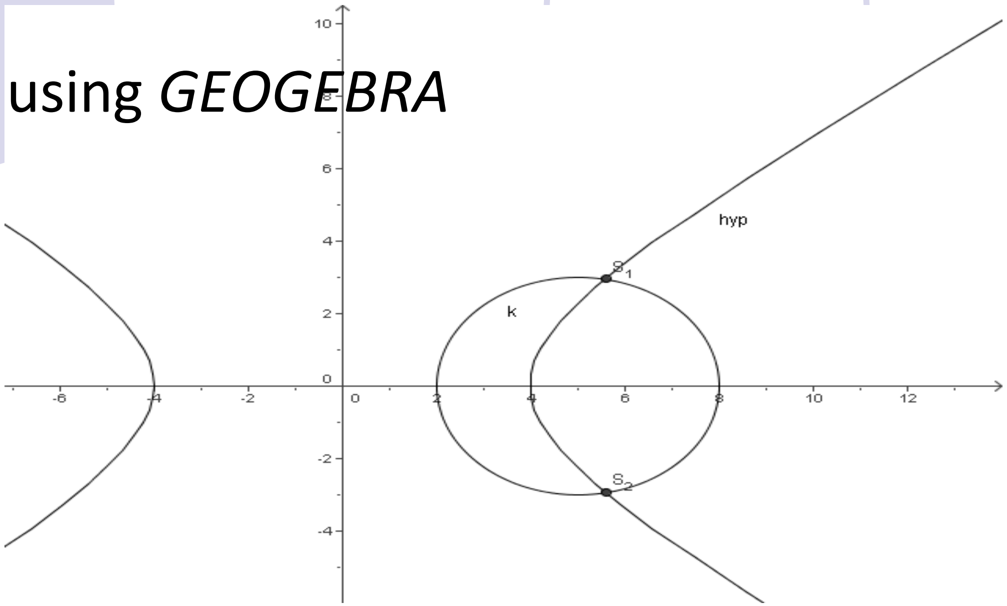
Abstraction of findings 2:

1 x 50 min

- calculation of the 1st and 2nd cosmic velocity by using the equation above
- constructing conic sections using *GEOGEBRA (www.geogebra.at)*



Educational Phase 4

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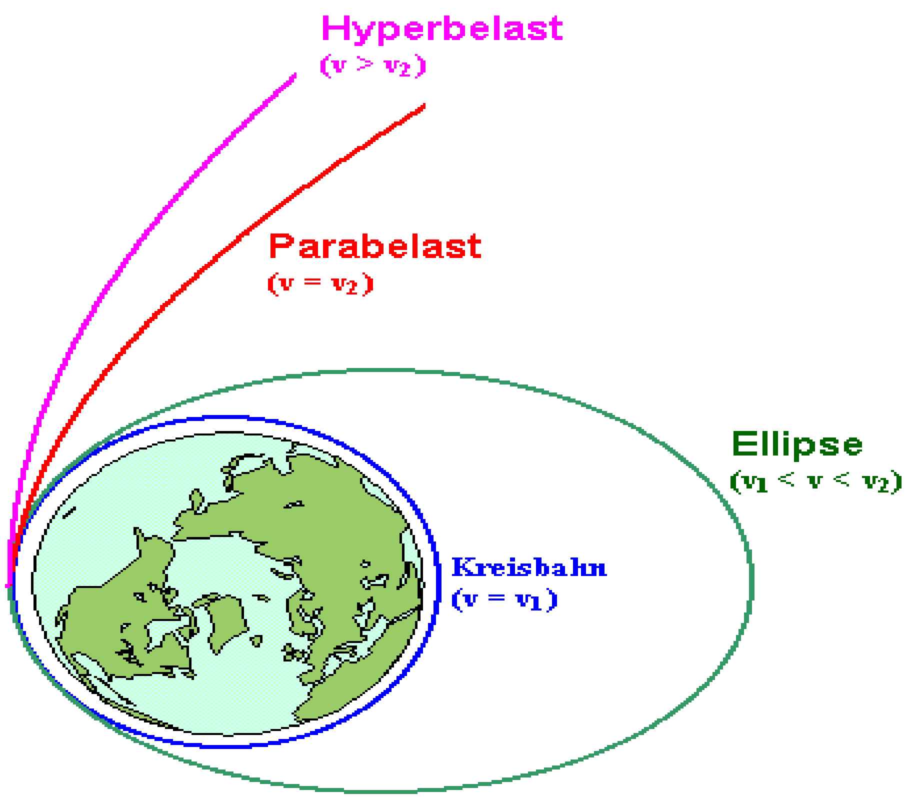
$$\frac{m \cdot v_1^2}{r_{Erde}} = G \cdot \frac{m \cdot M_{Erde}}{r_{Erde}^2} \Rightarrow$$

$$v_1 = \sqrt{\frac{G \cdot M_{Erde}}{r_{Erde}}}$$

$$E_{kin,2} = 0 - \left(- G \cdot \frac{m \cdot M_{Erde}}{r_{Erde}} \right)$$

$$\frac{1}{2} \cdot m \cdot v_2^2 = G \cdot \frac{m \cdot M_{Erde}}{r_{Erde}}$$



[9] From http://leifi.physik.uni-muenchen.de/web_ph11/umwelt-technik/10_gravfeld/index.htm

$$v_2 = \sqrt{\frac{2 \cdot G \cdot M_{Erde}}{r_{Erde}}} = \sqrt{2} \cdot v_1$$

Educational Phase 5

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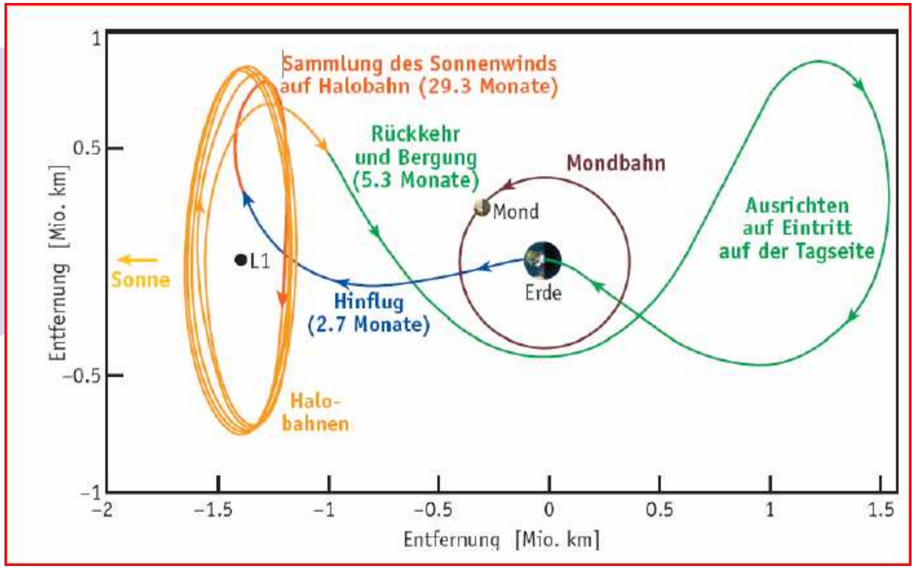
Consolidation: 1 x 50 min

- discussion of evolving problems
- calculating the height and velocity of a GPS satellite
- internet research: how long will it take for voyager 1 to leave the solar system
- internet research: find the trajectory of the spacecraft GENESIS



[10] Trajectory of spacecraft GENESIS; From „Sterne und Weltraum 7/2003“

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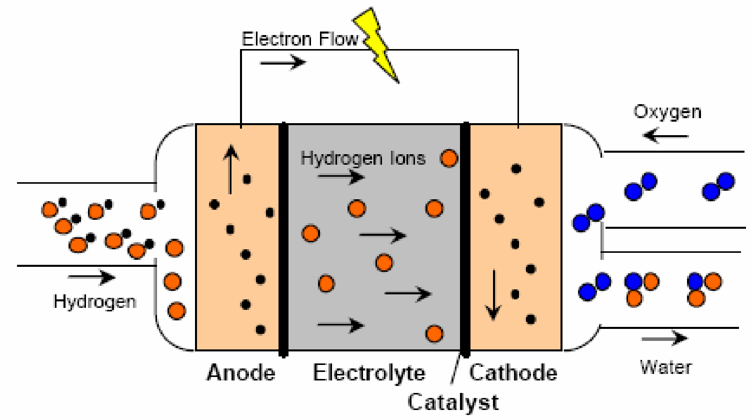
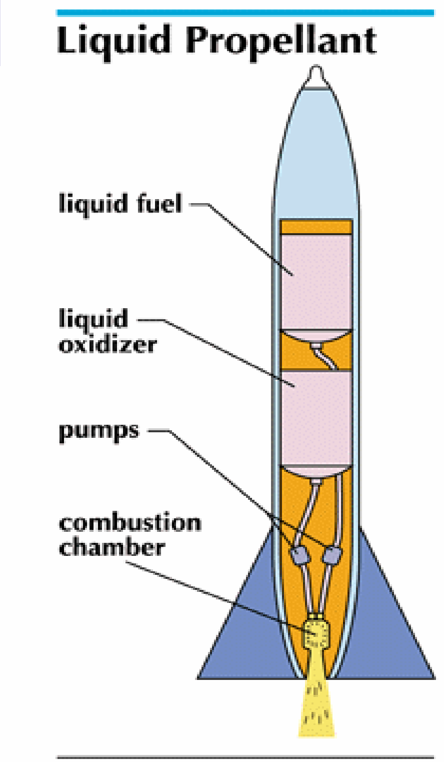
$$2\ H_2 + O_2 \rightarrow 2\ H_2O + \text{ENERGY}$$

Regarding spacecrafts, this chemical reaction is essential in two ways:

1) launch of spacecrafts: propulsion

2) power supply on board: fuel cell





[12] From http://student.britannica.com/comptons/article-207401/rocket