Lab activity 4º ESO

Linear uniform accelerated motion inquiry

Purpose

- To measure physical quantities of the LUAM
- To check the Kinematics equations

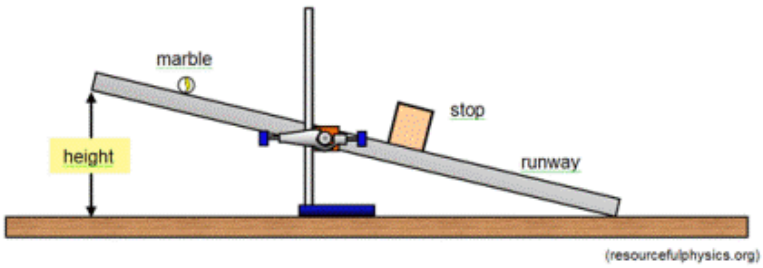
Theory

Linear uniformly accelerated motion is one, which has the same acceleration. Displacement depends on time squared because the particle travels at greater speed over time

Equipment needed

Steel ball (marble), ramp, photogates, stand, clamp, rod

Procedure



Roll down a ball along a ramp as it is shown in the picture. Measure the time taken for the ball to cover a distance at least three times to reduce uncertainties. Change the stop place and repeat the measurement for five different distances. As the motion is uniformly accelerated, the distance depends on time squared

$$s = s_o + v_o .t + \tfrac{1}{2} .a.t^2 \quad \Rightarrow \quad s = \tfrac{1}{2}. a.t^2$$

Data process

- Make a table showing distance, time, average time & uncertainty, time squared and acceleration
- Determine the average acceleration and its uncertainty by means of the half range
- Plot a graph of distance versus time squared. Draw a trend line

Questions

- How can you check that a motion is uniformly accelerated?
- Does the outcome change when we use a different ball?
- What will happen when the slope of the ramp changes?

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Lab activity 4º ESO

Hooke´s Law

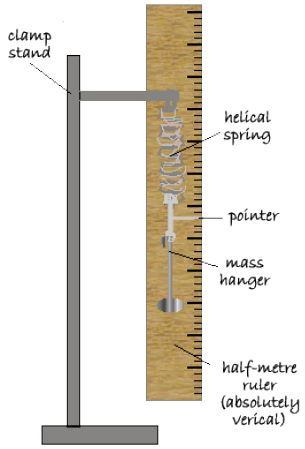
Purpose

- To check Hooke´s law
- To measure the spring constant

Theory

Hooke´s law explains the elastic properties of simple systems. According to its statement, stretching of a spring is proportional to the force acting upon it. The ratio of force to extension of the spring is called spring constant and it is measured in $N.m^{-1}$.

$$F = k.\Delta x$$



Equipment needed

Stand, rod, clamp, spring, tape measure, mass hanger, loads

Procedure

Hang a spring from a fixed point and measure its length. Extend it placing different weights at the other end of the spring. Measure the stretching of the spring.

Data process

- Record your data in a table showing mass, force (weight = m.g), length, extension and spring constant
- Determine the average spring constant and its uncertainty by means of the half range
- Plot a graph of force versus extension of the spring. Draw a trend line

Questions

- What is the difference between mass and weight?
- What happens when a great load is hung from a spring?

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Lab activity 4º ESO

Force of friction inquiry

Purpose

- To check that friction depends on the type of material, but not on the area
- To determine the coefficient of friction

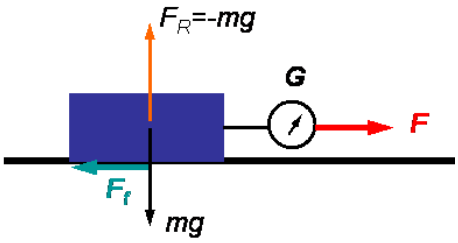
Theory

If we move a body at small velocities, we can admit that the force of friction depends on the normal reaction force and the type of surface, but not on velocity or area in contact.

F = μ.N

Equipment needed

Wood block of different surfaces, loads, dynamometer & precision balance



Procedure

We measure the force required to move a block on the laboratory bench. First of all we must test different types of surfaces so as to check the dependence on the type of material. Then, we have to test different areas in contact. Finally we put several loads on the block and test different weights

Data process

- Record your data showing area or kind of surface and force of friction
- Record your data in a table showing mass, weight, force of friction and coefficient of friction
- Determine the average coefficient of friction and its uncertainty by means of the half range
- Plot a graph of force of friction versus weight. Draw a trend line

Questions

- Does the force of friction depend on the type of material?
- Does it depend on the area in contact?
- What are the differences between static and kinetic coefficient of friction?
- How can you test whether the force of friction depends on velocity?

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Lab activity 4º ESO

Torque and lever law

Purpose

- To measure the torque of a force
- To check the lever law
- To check the equilibrium conditions of a system

Theory

Torque or momentum of a force about a point or fulcrum is a physical quantity, which refers to the turning effect of a force applied to a body. In other words, torque describes the lever law, which states that the effect of a force is equal to the product of force and length of the arm. Mathematically,

M = r.F (N.m = Joule)

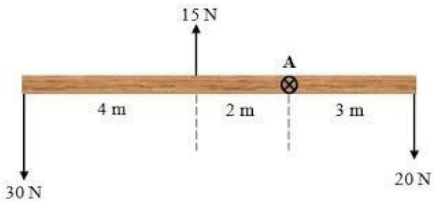
A system is at equilibrium when every forces and torques are balanced

$$\sum \vec{F} = 0 \qquad \sum \vec{M} = 0$$

Equipment needed

Stand, clamp, rod, tape measure, mass hanger, loads, iron lever

Procedure



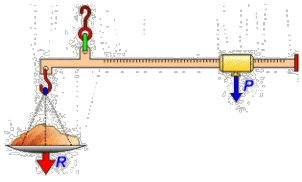
Attach two mass hangers to both sides of a lever. Hang one of the mass hangers at different points of the lever and record the mass required to balance the lever and the distances to the centre. Repeat the process at different distances

Data process

- Record your data in a table showing distances, masses, forces and torques
- Plot a graph of force versus length of the arm. Draw a trend line
- Determine the average torque and its uncertainty by means of the half range

Questions

- What are the main types of levers? Give some examples
- Comment this Archimedes´ sentence: "*Give me a place to stand on, and I will move the Earth*"
- Explain how a steelyard balance works



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Lab activity 4º ESO

Hydrostatic pressure & Archimedes´ law

Purpose

- To check hydrostatic pressure and Archimedes law
- To determine the pressure inside a fluid
- To calculate the density of a liquid by two different methods, checking results

Theory

Every fluid exerts a pressure which is proportional to its density and the height of the column of fluid

$$P = \rho.g.h$$

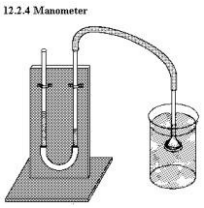
Archimedes´ law states that the buoyant force equals to the weight of the amount of fluid displaced by a body, so it is proportional to the density of the fluid

$$F_B = \rho.V.g$$

Equipment needed

Stand, rod, clamp, tape measure, bodies of different volumes, graduated cylinder, dynamometer, U-shaped tube, precision balance

Procedure



First of all, place the end of a flexible plastic tube at different depths of a sample of water so as to determine its pressure by means of the difference of height between both columns of liquid. Consider that density of ethanol is 780 $kg.m^{-3}$.

Then, determine the buoyant force of a body by comparing its weight in the atmosphere and its experimental weight in water.

Data process

- Record your data in a table showing depth of water, difference of height between the U-shape tubes, pressure and density of water
- Determine the average density of water and its uncertainty by means of the half range
- Plot a graph of pressure versus depth. Draw a trend line
- Record your data in a table showing weight, weight in water, buoyant force, volume and density of water
- Determine the average density of water and its uncertainty by means of the half range
- Plot a graph of buoyant force versus volume. Draw a trend line

Questions

- What is the boiling point of water in Madrid? Give an explanation and estimate the boiling point of water at the top of the Everest
- Explain how an altimeter works
- Explain the invention, way of working and boiling point of a pressure cooker

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Lab activity 4º ESO

Pendulum enquiry

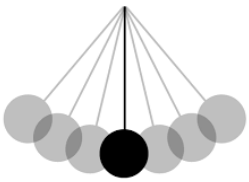
Purpose

- To test different variables which could affect to the period of a pendulum
- To understand the difference between independent, dependent and controlled variables
- To determine gravity on Earth

Theory

A pendulum is a load attached to a string which swings periodically. It can be used to determine gravity, by means of the equation

$$g = 4\pi^2 . \frac{l}{T^2}$$



Pendulum Swing

Equipment needed

Stand, rod, mass hanger, string precision balance and chronometer

Procedure

First of all, we test different masses adding loads to the mass hanger and keeping the same length, as controlled variable. Then we test different lengths keeping the same mass as controlled variable

Data process

- Record your data in a table, showing masses and periods
- Plot a graph of period versus mass. Does period depend on mass? Why?
- Record your data in a table, showing length, period, period squared and gravity
- Plot a graph of period versus length. Does period depend on length?
- Plot a graph of period squared versus length. Draw a trend line
- Determine the average gravity and its uncertainty by means of its half range

Questions

- What is a pendulum clock? How can you fix this kind of clock in case of delaying?
- In 1851 L. Foucault carried out an experiment in Paris Observatory in order to show the rotation of the Earth. What is a Foucault pendulum? How can it show the rotation of the Earth?

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Lab activity 4º ESO

Conservation of energy law (I)

Purpose

- To check conservation of energy law
- To estimate the work done by the force of friction
- To estimate the coefficient of friction

Theory

Conservation of energy law states that mechanical energy remains constant when all the forces applied to a body are conservative. Particularly, the kinetic energy gained by an object is equal to the potential energy stored at a height

$$^1/_2 . mv^2 = mgh \qquad\qquad v = \sqrt{2gh}$$

On the other hand, an object can dissipate mechanical energy into heat when a non-conservative force is applied onto an object, such as force of friction. In this case

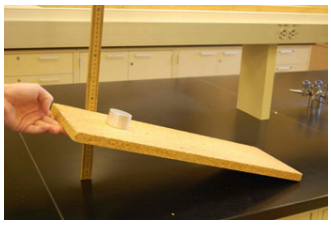
$$W = F_f . s = E_o - E = mgh - {}^1/_2 . mv^2$$

Equipment needed

Rubber or metal cylinder, ramp, photogates, stand, clamp, rod

Procedure

Drop a rubber from a point and measure the speed at the bottom or, alternatively, the time taken for the ball to cover this distance. Then, let an iron cylinder fall down on a ramp and repeat the measurements from five different heights



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Data process

- Determine kinetic energy and potential energy of the rubber and compare results
- Record your data in a table showing height, potential energy, speed, kinetic energy, loss of energy, distance covered and force of friction
- Determine the average force and its uncertainty by means of the half range
- Plot a graph of loss of energy versus distance. Draw a trend line

Questions

- What are the most important conservative forces? Give an example of a non conservative one
- Explain the conversion of energy which occurs when a conservative or non conservative force is applied on an object

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Lab activity 4º ESO

Conservation of energy law (II)

Purpose

- To check conservation of energy law
- To estimate the speed at which water flows
- To estimate gravity

Theory

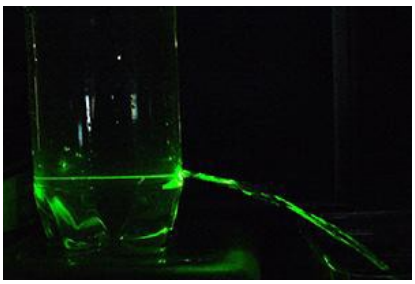
Conservation of energy law states that mechanical energy remains constant when all the forces applied to a body are conservative. Particularly, the kinetic energy of the stream of water is equal to the potential energy stored in the mass of water

$$^1/_2 . mv^2 = mgh \qquad v = \sqrt{2gh}$$

This is the basis the generation of energy in a hydroelectric power station

Equipment needed

Bottle of PET, container, measuring tape



Procedure

Make a little hole in a plastic bottle, place it on the lab bench and pour water through the hole. Water will be collected in a container placed on the floor.

As the level of water decreases, the speed of the stream of water will be reduced and the horizontal range as well.

As we can determine the time taken for the water to arrive to the ground, we can also estimate the velocity of the stream

$$s = \frac{1}{2} g t^2 \qquad t_{fall} = \sqrt{\frac{2s}{g}} \qquad x = v.t$$

Data process

- Record your data in a table showing height, range, horizontal speed and gravity
- Determine the average gravity and its uncertainty by means of the half range
- Plot a graph of speed versus range. Draw a trend line

Questions

- What are the most important conservative forces? Give an example of a non-conservative one
- What are the tallest dams in the world?

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Lab activity 4º ESO

Reflection & refraction of light: Snell´s law

Purpose

- To check the reflection of light law
- To check Snell´s law
- To determine the index of refraction of glass

Theory

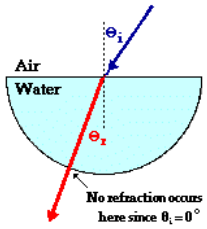
Reflection´s law was discovered by Euclid and Heron of Alexandria. It states that the angle of incidence equals to the angle of reflection. Snell´s law states that the sine of the angle of incidence is proportional to the sine of the angle of refraction.

$$n_1 . \sin \alpha_1 = n_2 . \sin \alpha_2 \qquad\qquad n = \frac{c}{v}$$

Index of refraction is the ratio of speed of light in vacuum to the speed of light in a medium and it measures how difficult light travels through a medium

Equipment needed

Laser pointer, Hartl disc, semicircular lens, mirror.



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Procedure

Place a pointer on a Hartl disc and point to the mirror. Measure directly the angle of incidence and the angle of reflection.
Repeat the process using a semicircular lens, measuring the angle of incidence and the angle of refraction. Point the laser from the disc to the air trying to find the critical angle, when there is no refraction from glass to air.

Data process

- Record your data in a table showing angle of incidence, angle of reflection and angle of refraction
- Plot a graph of angle of reflection versus angle of incidence. Draw a trend line
- Record your data in a table showing sine of angle of incidence, sine of angle of refraction and index of refraction
- Plot a graph of sine of angle of incidence versus and sine of refraction. Draw a trend line
- Determine the average index of refraction and its uncertainty by means of the half range
- Determine the critical angle and compare its magnitude with the experimental one

Questions

- Try to explain what a mirage is and how it occurs
- Why can you hear sounds very clear at night?
- Try to explain the basis of the optical fibre

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Lab activity 4º ESO

Chemical reactions: conservation of mass law

Purpose

- To determine masses of reactants and products
- To check conservation of mass´ law
- To check constant proportions law

Theory

In 1774, Lavoisier stated the conservation of mass´s law:

"The mass of the reactants is equal to the mass of products"

In 1804, Proust stated the law of definite proportions:

"Every chemical substance, contains the same ratio of its elements"

Equipment needed

Balloons, erlenmeyer, precision balance, stirring rod, 0,1 M solution HCl, calcium carbonate, graduated cylinder

Procedure

Pour 10 ml of HCl solution in an erlenmeyer. Add a mass of calcium carbonate and close the balloon to collect the gas released in the reaction. Compare the mass of reactants before the reaction and the mass of the products.

Determine the mass of calcium carbonate reacted in the process.

Repeat the same with different volumes of calcium carbonate.

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Data process

- Record your data in a table showing volume of HCl, mass of the reactants, mass of the products, mass of gas, initial mass of carbon dioxide, final mass, reacted mass
- Plot a graph of mass of calcium carbonate versus moles of HCl
- Draw a trend line

Questions

- What is the ratio of moles of HCl to moles of calcium carbonate?
- Can you predict the formula for calcium chloride?

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Lab activity 4º ESO

Reaction rate

Purpose

- To prepare a set of solutions of different concentrations
- To estimate the rate of reaction
- To determine the order of reaction

Theory

The rate of a chemical reaction is the amount of substance produced per unit of time. It measures how fast or slow the reaction takes place.
Reaction rate depends of different quantities:

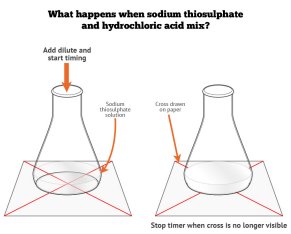
- Temperature: reaction rate increases when heating
- Concentration: reaction rate increases as concentration increases. The rate equation shows the link between rate and concentration $v = k.[Na_2S_2O_3]$

Equipment needed

Erlenmeyer, graduated cylinder, pipette, test tubes, test tube rack, chronometer, HCl (0,2 M) & $Na_2S_2O_3$ (0,25 M) solutions

Procedure

Sodium thiosulphate reacts with hydrochloric acid and yields colloidal sulphur, sulphur dioxide and water: $Na_2S_2O_3$ (aq) + HCl (aq) → S (s) + SO_2 (g) + H_2O + NaCl (aq)



It is very easy to measure the time taken for the reaction to take place because the transparent solution turns cloudy because of sulphur production.
Prepare solutions of hydrochloric acid of different concentrations by mixing acid and water in different proportions. Mix these solutions with sodium thiosulphate in an erlenmeyer and start measuring time. Place the solution on a piece of paper with a black cross on it and stop timing when the cross is hidden by the solution

$Na_2S_2O_3$ volume (ml)	10	8	6	4	2
Volume of water (ml)	-	2	4	6	8
Hydrochloric acid volume (ml)	5	5	5	5	5

Data process

- Record your data in a table showing volumes of solutions, time, reciprocal of time, concentration of sodium thiosulphate
- Plot a graph of reciprocal of time versus concentration of sodium thiosulphate. Draw a trend line

Questions

- Explain the link between temperature and the reaction rate

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Lab activity 4º ESO

Measurement of heat of reaction

Purpose

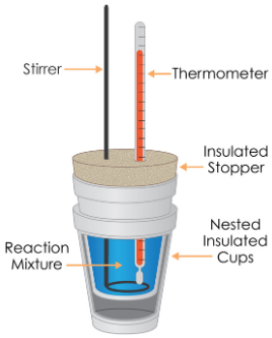
- To test whether a reaction is endothermic or exothermic
- To measure the heat of a reaction
- To determine the heat of solubilisation

Theory

As some chemical bonds are broken or produced in a chemical reaction, an amount of energy is involved in this kind of processes. An ***exothermic reaction*** releases heat and increases temperature of the reaction mixture because the energy of the products is lower than the energy level of reactants. On the contrary, an ***endothermic reaction*** is the opposite process: it absorbs energy and decreases temperature of the solution since the energy of reactants is lower than the energy of products.
Heat released or absorbed in 100 g of water is $Q = m.C.\Delta T = 418.\Delta T$, since C = 4180 $J.kg^{-1}.K^{-1}$ and m = 0,1 kg

Equipment needed

Calorimeter, thermometer, erlenmeyers, graduated cylinder, precision balance, stirring rod, ammonium nitrate, sodium hydroxide



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Procedure

Pour 100 ml of water in a calorimeter and check its temperature.
Solve an amount of sodium hydroxide, stirring in case it is required.
Determine the change of temperature of the solution and its amount of heat.
Pour 100 ml of water in a calorimeter and check its temperature. Solve an amount of ammonium nitrate, stirring in case it is required. Determine the change of temperature of the solution and its amount of heat released or absorbed

Mass of salt (g)	2,5	5	7,5	10	12,5	15
Volume of water (ml)	100					

Data process

- Record your data in a table, showing mass of salt, number of moles, change of temperature, heat released or absorbed and heat of solubilisation ($kJ.mole^{-1}$)
- Determine the average of the heat of solubilisation, expressed in $kJ.mole^{-1}$.
- Plot a graph of heat versus number of moles. Draw its trend line

Questions

- Explain how you feel fresher when your sweat evaporates
- What is the sign of heat of an exothermic reaction?. What is the sign of the heat of an endothermic reaction?

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Lab activity 4º ESO

Preparation of solutions: acids & bases

Purpose

- To prepare a set of solutions of different concentrations
- To understand the properties of acids and bases

Theory

Acids are substances, which solve metals or calcium carbonate. On the other hand, bases are substances, which react with acids and yield a salt. Brönsted stated that acids release hydrogen cations (H^+, also known as protons) but bases accept protons. The acidity of a solution can be measured using the pH scale

$$pH = - \log [H^+]$$

pH can be measured using indicators, substances which have different colour when the acidity changes, or a pHmeter. Neutral solutions have a pH = 7. Acidic solutions have a pH < 7, which means that $[H^+] > 10^{-7}$ M and basic solutions have a pH > 7

Equipment needed

Test tubes, test tube rack, pipette, pHmeter, beaker, calcium carbonate, HCl solution 0.2 M, NaOH solution 0.2 M

Procedure

Prepare a set of test tubes mixing different proportions of HCl and NaOH solutions as it is shown below:

NaOH volume (ml)	0	3	7	10	10	10	10
Volume of water (ml)	10	7	3	0	3	7	10
HCl volume (ml)	10	10	10	10	7	3	0

Test each mixture using a pHmeter, an indicator (red cabbage juice), and $CaCO_3$ reaction test.

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Data process

- Record your data in a table labelling each solution and showing pH, colour of indicator paper and reaction with calcium carbonate

Questions

- What is the effect of pH variation on proteins and fatty acids? How can it be applied in digestion processes?
- How can you manufacture indicator paper using cyanide (red cabbage juice)?