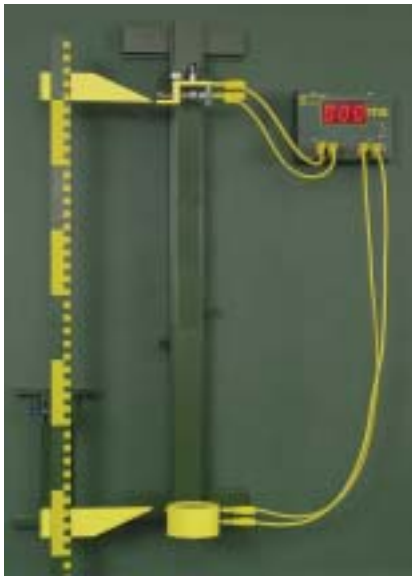
NTL innoSYSTEM

Experiment Manual



MECHANICS

simple fast safe

EXPERIMENT TITLES

Characteristics of Bodies (Measuring Physical Phenomena)

M 01 Measuring length– scale
M 02 Measuring length – sliding caliper
M 03 Measuring length – micrometer gauge
M 04 Measuring the volume of liquids
M 05 Measuring the volume of solid bodies by liquid displacement
M 06 Measuring the volume of gases
M 07 Diving bell
M 08 Beam balance
M 09 Digital scales with single dish
M 10 Measuring the density of solid bodies with the same mass
M 11 Measuring the density of solid bodies with the same volume
M 12 Measuring the density of liquids
M 13 Measuring the density of immiscible liquids
M 14 Density and temperature
M 15 Density and composition
M 16 Air density

Statics of Solid Bodies – Forces and Their Effects

M 17 Force changes shape
M 18 Mass and weight
M 19 Mass, weight and gravity
M 20 Weight and mass are proportional
M 21 Stretching an elastic band
M 22 Bending a flat spring
M 23 Hooke's law
M 24 Force and opposing force (action equals reaction)
M 25 Composition of equidirectional forces
M 26 Balance of forces
M 27 Composition of non-parallel forces
M 28 Force parallel to an incline
M 29 Resolution of force on an incline
M 30 Force components on an incline

Statics of Solid Bodies – Torque

M 31 Torsional effect of torque on rods
M 32 Characteristics of a torsion rod
M 33 Magnitude of directional angles in torsion rods
M 34 Balance of torque
M 35 Angle lever
M 36 Experimental model of an angle lever
M 37 Two-armed lever
M 38 Position and force direction not relevant for a two-armed lever
M 39 One-armed lever
M 40 Center of gravity
M 41 Center of gravity – swinging hammer
M 42 Types of balance
M 43 Creep strength
M 44 Apparatus for creep strength
M 45 Stability
M 46 Roly poly

Solid Bodies in Motion

M 47 Motion
M 48 Uniform linear motion – eddy current device
M 49 Uniform linear motion: same time – same distance
M 50 Velocity of a uniform linear movement
M 51 Law of time and distance applied to uniform linear motion
M 52 Non-uniform linear movement of a ball
M 53 Non-uniform motion – up- and downhill
M 54 Non-uniform linear motion – mean velocity
M 55 Law of time and distance applied to the accelerated uniform motion of a ball
M 56 Law of time and distance applied to the accelerated uniform motion of a wagon
M 57 Law of time and acceleration applied to the accelerated uniform motion of a ball
M 58 Law of time and acceleration applied to the accelerated uniform motion of a wagon
M 59 Newton's second law of motion

Friction

M 60 Static friction
M 61 Sliding friction
M 62 Rolling friction
M 63 Determining the friction coefficient
M 64 Friction and types of surfaces

Laws of Motion Applied to Air Cushions

Accelerated motion under constant force
Motion under inertia – uniform slippage
Uniform acceleration and slippage (relationship of time and distance)
Uniform acceleration and slippage (relationship of time and acceleration)
Collision exchanges

Inertia

M 65 Inertia and mass
M 66 A body's inertia is independent of its mass
M 67 Mass moment of inertia
M 68 Inertia of a mass
M 69 Interaction and mass
M 70 Interaction of opposing equal forces

Motion Change Due to Force

M 71 Impulse
M 72 Momentum
M 73 Law of interaction
M 74 Conserving momentum

M 75 Conserving momentum with equal masses
M 76 Conserving momentum with unequal masses
M 77 Repulsion – water outlet
M 78 Repulsion – air outlet
M 79 Segner waterwheel
M 80 Propeller drive
M 81 Repulsion – rocket engine
M 82 Model of a rocket
M 83 Elastic collision with an obstacle
M 84 Non-elastic collision
M 85 Free fall – gravity tube
M 86 Free fall – measuring gravitational acceleration
M 87 Horizontal and diagonal trajectories – stream of water
M 88 Horizontal and diagonal trajectories – shot-put
M 89 Principle of independence

Circular motion

M 90 Variations on building a centrifuge (hand- and motor-driven)
M 91 Centrifugal force – carousel
M 92 Centrifugal force – centrifugal container
M 93 Centrifugal force – floating ball
M 94 Centrifugal force – centrifuge
M 95 Centrifugal force – the earth's oblateness
M 96 Centrifugal regulator
M 97 Rotating liquids
M 98 Centrifugal force – a paradox
M 99 Rotating pendulum
M 100 Foucault's pendulum – overhead projection
M 101 Centrifugal force
M 102 Centripetal force
M 103 Centripetal force is dependent on mass, radius and angular velocity
M 104 Moment of inertia and distribution of mass
M 105 Conserving angular momentum
M 106 Bicycle as a gyroscope
M 107 Precession movement in a gyroscope
M 108 Gyroscope
M 109 Gyrocompass
M 110 Bodies rotating symmetrically

Work – Energy Conversion

M 111 Lifting work
M 112 Acceleration work
M 113 Potential energy
M 114 Potential energy – forming
M 115 Potential and tensional energy
M 116 Rotational energy
M 117 Conserving energy
M 118 Conserving energy in a pendulum
M 119 Kinetic energy
M 120 Potential energy – kinetic energy
M 121 Tensional energy – kinetic energy
M 122 Artesian wells
M 123 Maxwell's wheel
M 124 Friction and heat energy

Simple Machines

M 125 Fixed pulley
M 126 Moving pulley
M 127 Simple block and tackle
M 128 Block and tackle with four pulleys
M 129 Parallel block and tackle with four pulleys
M 130 Wheel and axle
M 131 Belt drive
M 132 Sprocket drive
M 133 Worm drive

Machines for Converting Energy

M 134 Waterwheel
M 135 Pelton turbine
M 136 Kaplan turbine

Power

M 137 Lifting work and power– windmill
M 138 Lifting work and power – motor

Introducing "Pressure" as a Term in Physics

M 139 Demonstrating pressure – the bar
M 140 Deformation depends on area

Pressure and Liquids

M 141 Pressure on different surfaces
M 142 Hydraulic press
M 143 Measuring hydrostatic pressure using immersion sensors of different shapes
M 144 Measuring hydrostatic pressure using Hartl's apparatus
M 145 Upward pressure
M 146 A hydrostatic paradox – ground pressure device
M 147 Distribution of pressure in liquids
M 148 Velocity of outflow
M 149 Lateral pressure and velocity of outflow
M 150 Communicating vessels
M 151 Watering can
M 152 Level measurement – hose leveling instrument
M 153 Comparing the density of immiscible liquids using a u-shaped tube

Pressure and gases

M 154 Pressure is dependent on area
M 155 Pressure change by density change
M 156 Measuring pressure change by density change
M 157 Pressure change by temperature change
M 158 Pressure increase – temperature increase
M 159 Liquid manometer
M 160 Piston manometer
M 161 Boyle's law
M 162 Demonstrating air pressure
M 163 Over- and underpressure

M 164 Measuring air pressure – model barometer
M 165 Measuring the vacuum in a water-jet pump
M 166 Effects of air pressure
M 167 Determining outside air pressure
M 168 Measuring air pressure in a balloon
M 169 Siphon
M 170 Vacuum pump
M 171 Pressure pump

Buoyancy in Liquids and Gases

M 172 Buoyancy in a liquid
M 173 Measuring buoyancy
M 174 Buoyancy – determining forces
M 175 Buoyancy of bodies with different densities
M 176 Floating – hovering – sinking
M 177 Areometer
M 178 Model of a submarine
M 179 Floating Styrofoam ball
M 180 Archimedes's principle
M 181 Buoyancy in air

Molecular Forces – Surface Tension

M 182 Elastic – plastic – brittle
M 183 Cohesion and adhesion
M 184 Capillary attraction
M 185 Capillary action – surface tension
M 186 Measuring surface tension of liquids
M 187 Plane soap film
M 188 Osmotic pressure

Flowing Liquids and Gases

M 189 Vaporizer
M 190 Measuring the vacuum in a vaporizer
M 191 Pressure distribution in flowing liquids – tubes of a constant diameter
M 192 Pressure distribution in flowing liquids – tubes of varying diameters
M 193 Model of an anemometer
M 194 Measuring flow velocity
M 195 Dynamic pressure of an air current
M 196 Flow pressure – Venturi tube
M 197 An aerodynamic paradox
M 198 Buoyancy in air currents
M 199 Buoyancy of air foils with a flat and steep angle of incidence
M 200 Drag in air foils
M 201 Distribution of pressure on an air foil
M 202 Air resistance and the shapes of bodies
M 203 Air resistance and the diameters of bodies
M 204 Air resistance and bodies' surface types

Vibrations and Waves

M 205 String pendulum
M 206 Spring pendulum
M 207 Determining the elasticity constant
M 208 Reversion pendulum
M 209 Steiner's law
M 210 Torsion pendulum: determining the moment of inertia
M 211 Coupled pendulum
M 212 Resonance of a spring pendulum
M 213 Harmonic torsional vibration
M 214 Moment of inertia and duration of torsional vibration
M 215 Moment of inertia of a hollow and solid body
M 216 Standing transverse waves
M 217 Standing longitudinal waves
M218 Diffusion of longitudinal waves: magnetic wave device
M 219 Standing concentric waves
M 220 Vibrating reed frequency meter
M 221 Standing waves with a fixed end
M 222 Wave reflection from a fixed end
M 223 Wave reflection from a loose end
M 224 Wave interference
M 225 Undamped waves
M 226 Damped waves
M 227 Wave reflection from a fixed end: destructive interference
M 228 Wave reflection from a loose end: constructive interference
M 229 Changing wave length

Experiments with the Water Wave Generator

M 230 Concentric waves
M 231 Smooth waves
M 232 Reflection from a smooth obstacle
M 233 Refraction in a prism
M 234 Reflection in a concave mirror
M 235 Effect of a lens
M 236 Doppler effect
M 237 Interference of two concentric waves
M 238 Diffraction at a trough
M 239 Diffraction at a double trough
M 240 Chaotic pendulum

MEASURING DEVICES – POWER SUPPLIES

MECHANICS

DM722-1N	Box - Newtonmeter 0 – 20 N, 0 – 2 kg
DM723-1N	Box - Millinewtonmeter 0 – 20 mN, 0 – 2 g
DE722-1D	Box - Manometer absolute
DE722-2D	Box - Manometer differential
DE722-1W	Box - Stopwatch
DE722-2W	Remote switch for box - stopwatch
P3120-1D	Box - Time measurement device
P3120-2F	Box - Battery for P 3120-3L/3R
DM341-1T	Box - Time measurement device for falling-sphere device
DT816-2A	Box - Anemometer

ACOUSTICS

DE722-1F	Box - Frequency counter
DW340-2M	Box - Measurement microphone
DW275-1M	Box - Sound level measuring device
P3180-LF	Box - AF transformer

ELECTROSTATICS

P3127-1V	Box - High-voltage device 0 – 18 kV
DE722-1H	Box - Electrostatic voltmeter 0 – 18 kV

ATOMIC PHYSICS

DE722-1G	Box - Geiger-Mueller counter

OPTICS

DL722-2L	Box - Light meter
DL100-3L	Box - Laser 635 nm

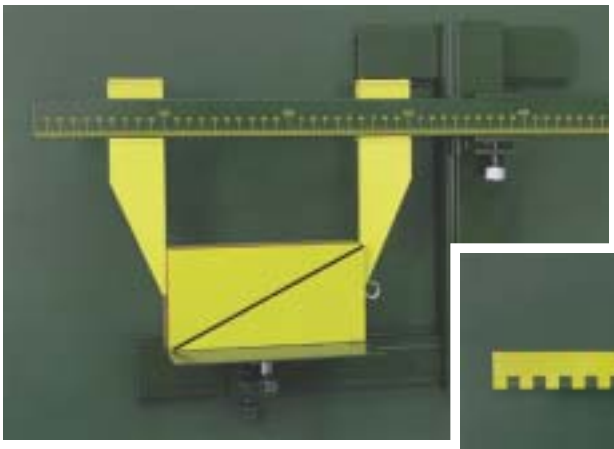
CHEMISTRY

P3120-1P	Box - pH meter
DE722-1L	Box – Conductimeter

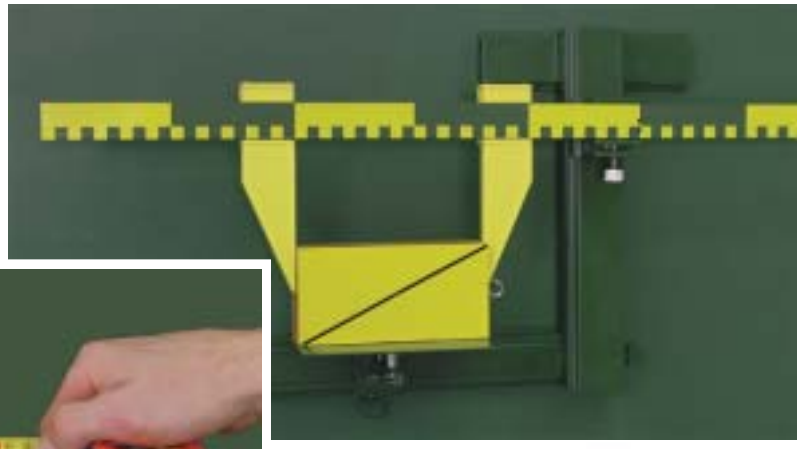
ELECTRICITY

Power Supplies and Measuring Instruments

cf. catalogue of experiments and instruments PHYSICS 0106, pp. 103 ff

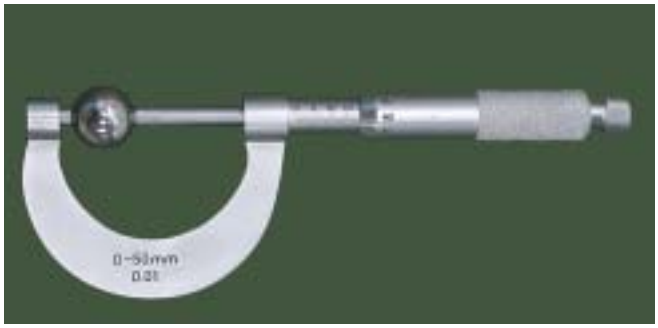


01 Measuring length scale



02

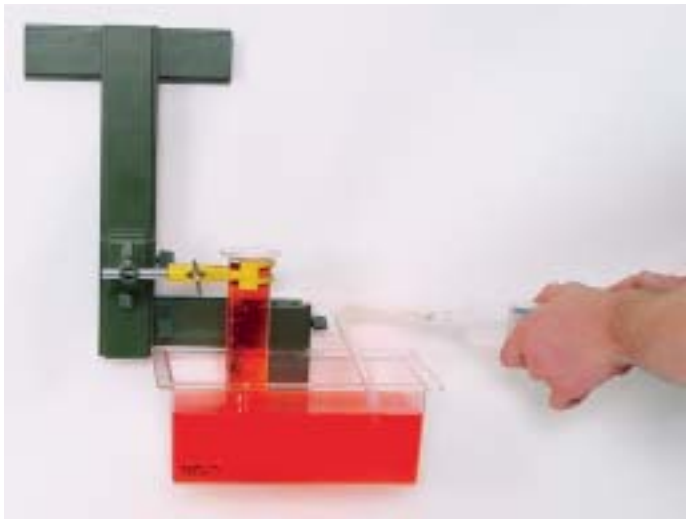
Measuring length sliding caliper



03

Measuring length micrometer gauge

04 Measuring the volume of liquids



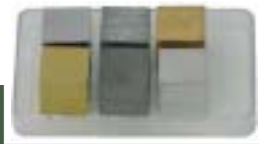
06 Measuring the volume of gases

05 Measuring the volume of solid bodies by liquid displacement

07 Diving bell

09 Digital scales with single dish

08 Beam balance



10 Measuring the density of solid bodies with the same mass

11
Measuring the density of solid bodies with the same volume

12
Measuring the density of liquids

13
Measuring the density of immiscible liquids

14
Density and temperature

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15 Density and composition

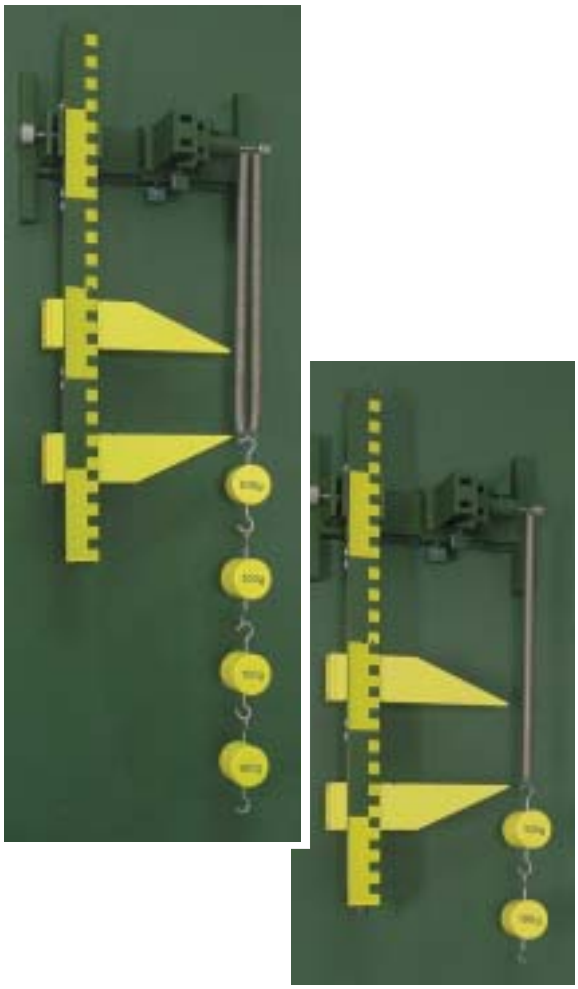
16 Air density

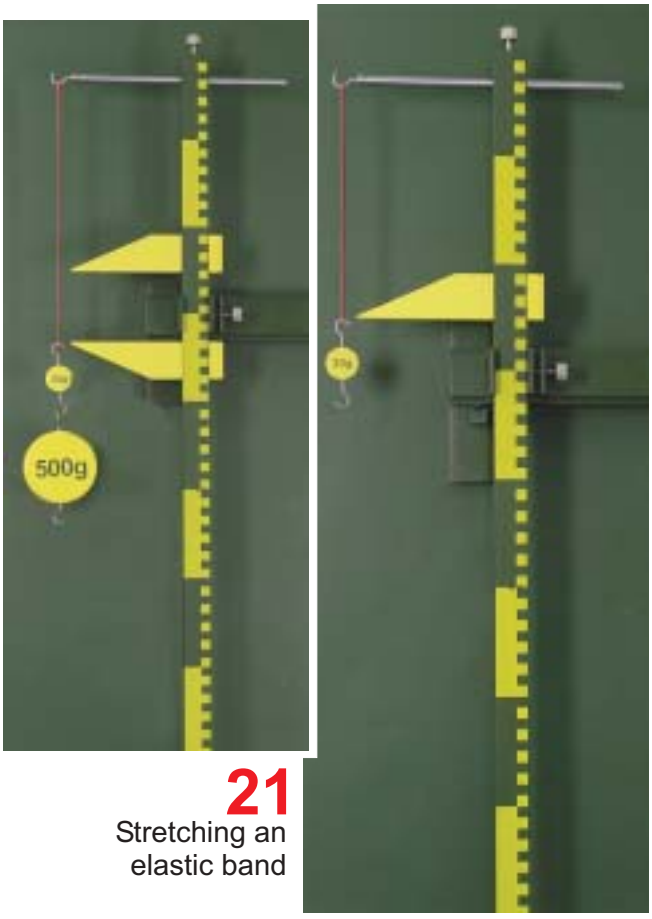
17 Force changes shape

19 Mass, weight and gravity

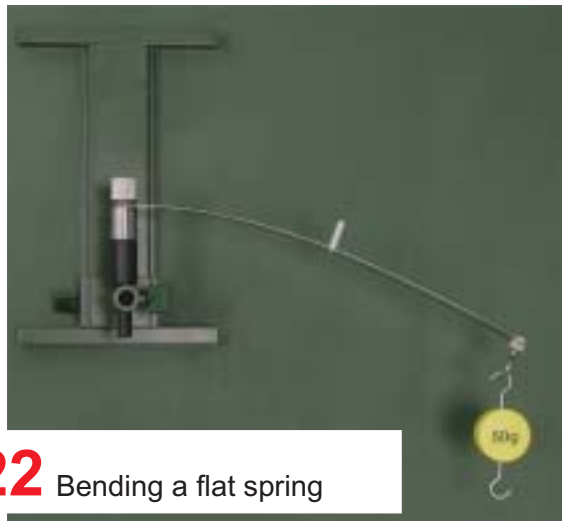
18 Mass and weight

20 Weight and mass are proportional





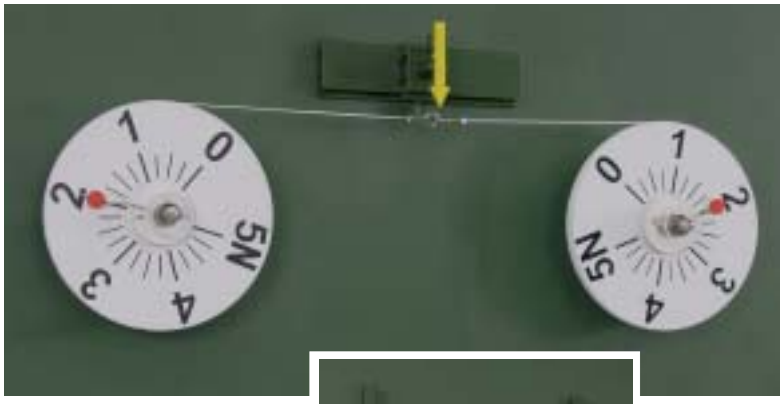
21 Stretching an elastic band

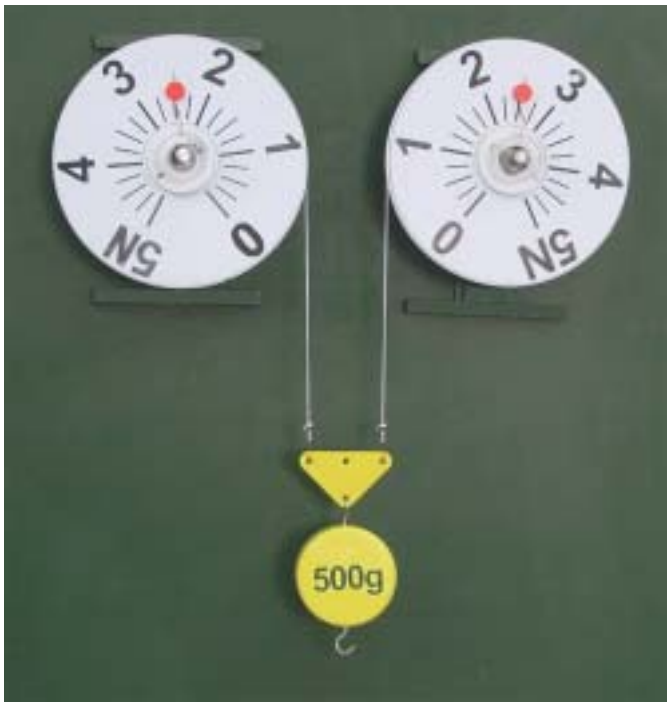


22 Bending a flat spring

23 Hooke's law

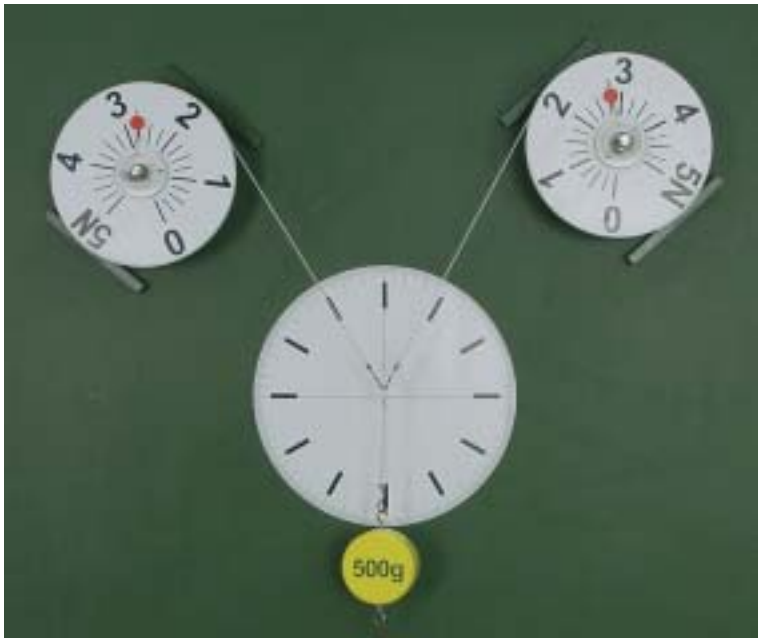
24 Force and opposing force (action equals reaction)



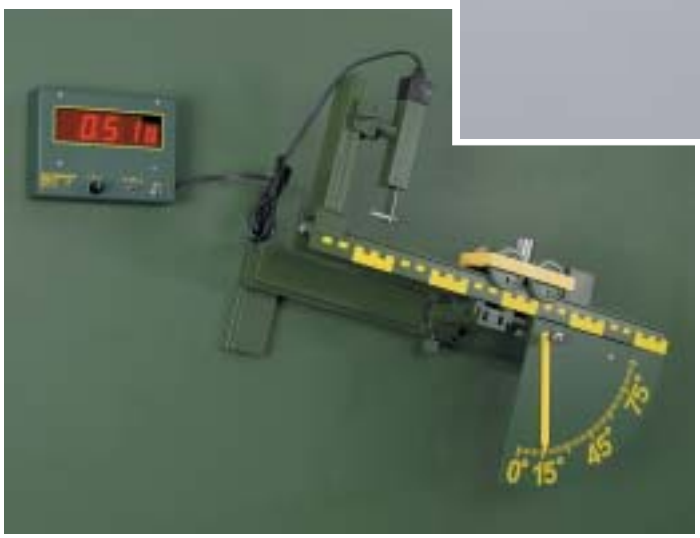


25 Composition of equidirectional forces

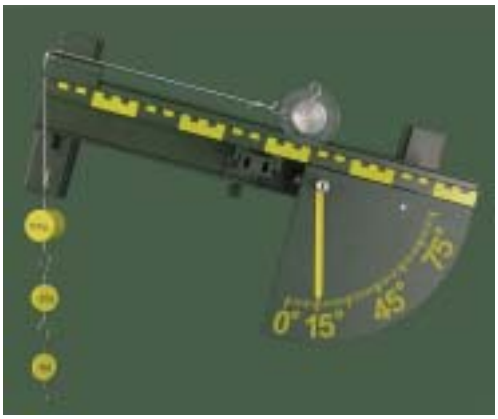
26 Balance of forces



27 Composition of non-parallel forces

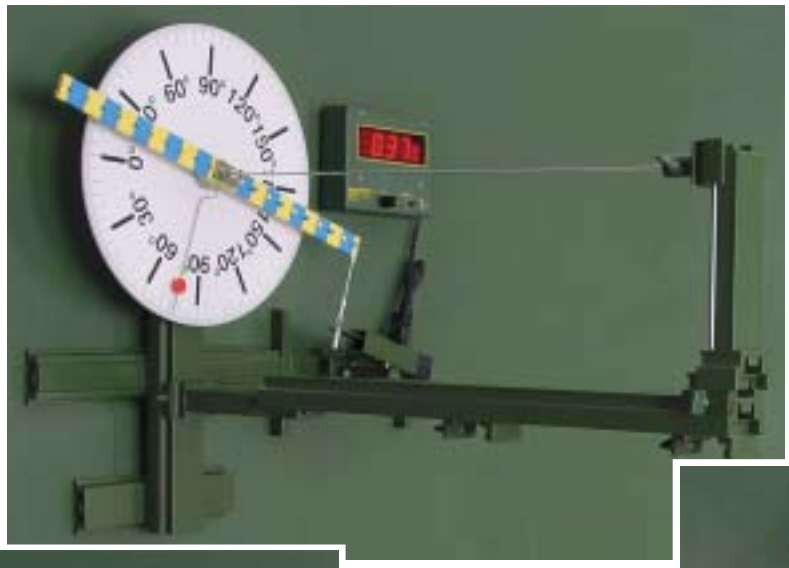


28 Force parallel to an incline



29 Resolution of force on an incline

30 Force components on an incline

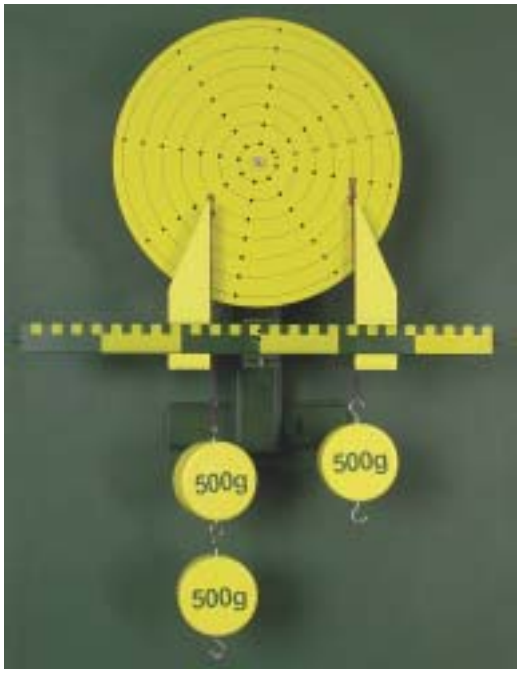


31 Torsional effect of torque on rods

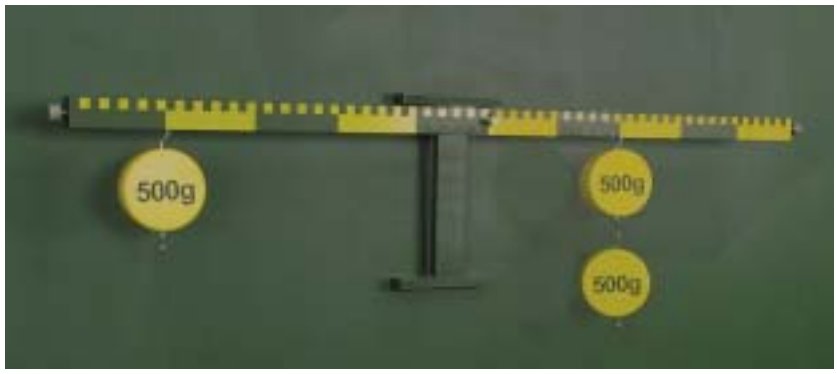
32 Characteristics of a torsion rod

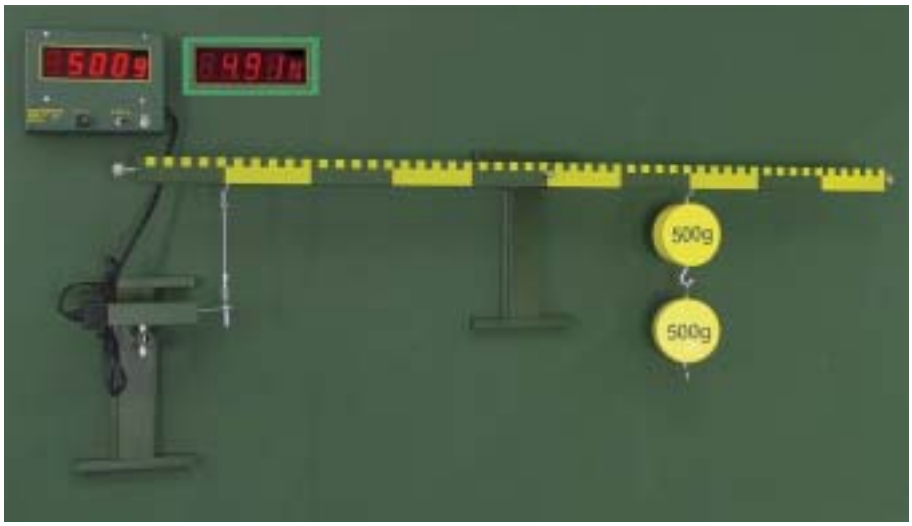
33 Magnitude of directional angles in torsion rods

35 Angle lever

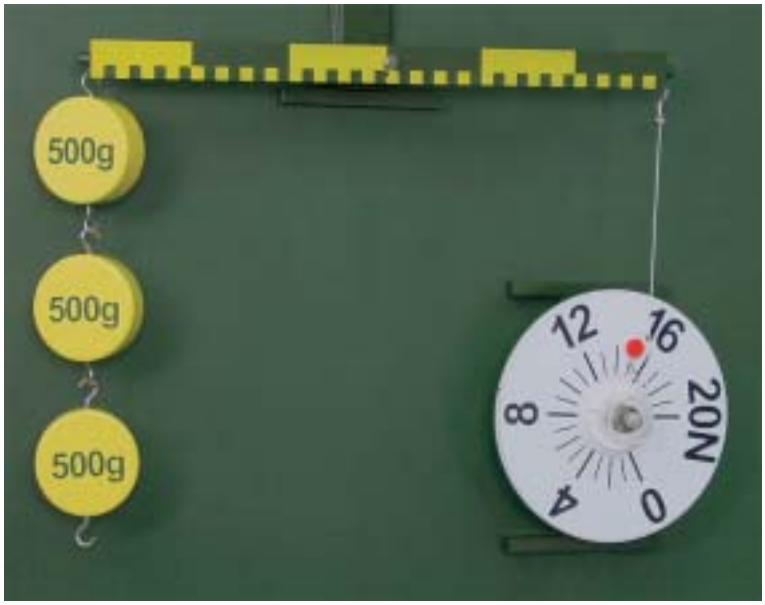


34 Balance of torque



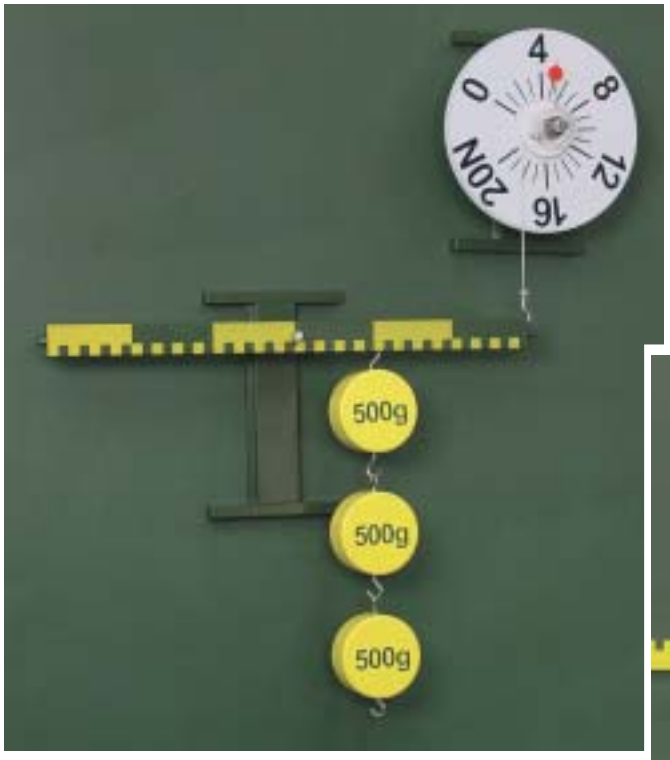


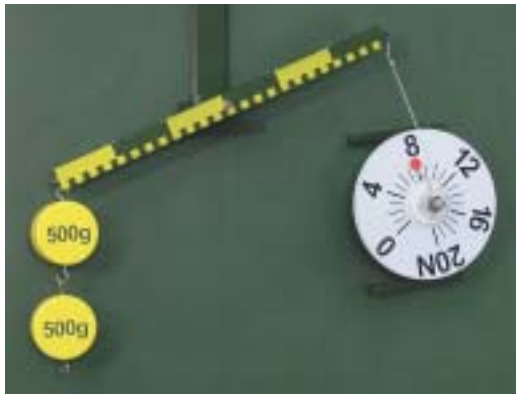
37 Two-armed lever



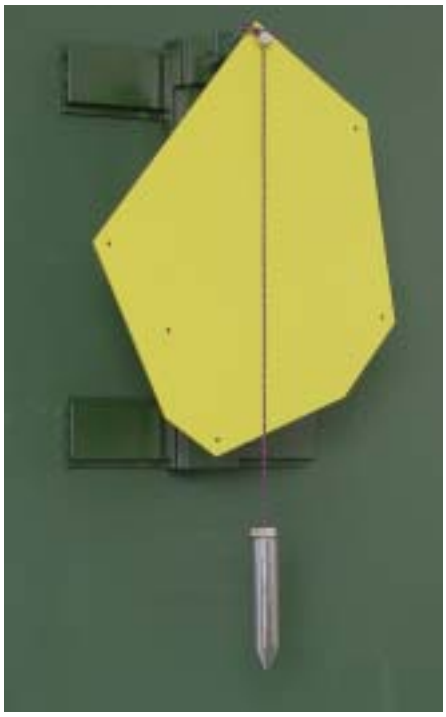
36 Experimental model of an angle lever

39 One-armed lever





38 Position and force direction not relevant for a two-armed lever



40 Center of gravity

41 Center of gravity swinging hammer

MECHANICS

42 Types of balance

43 Creep strength

44 Apparatus for creep strength

45 Stability

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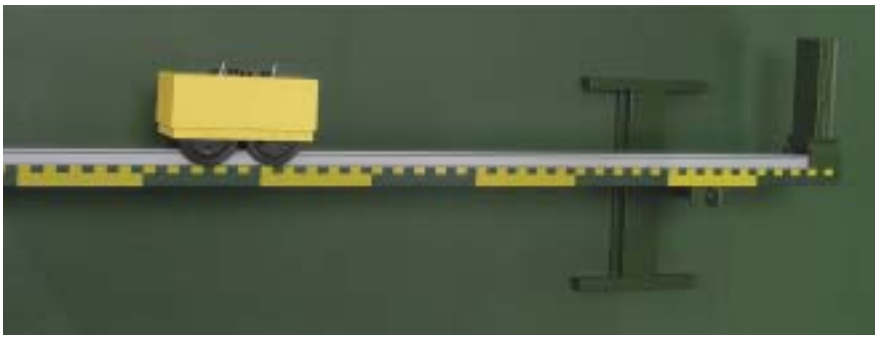
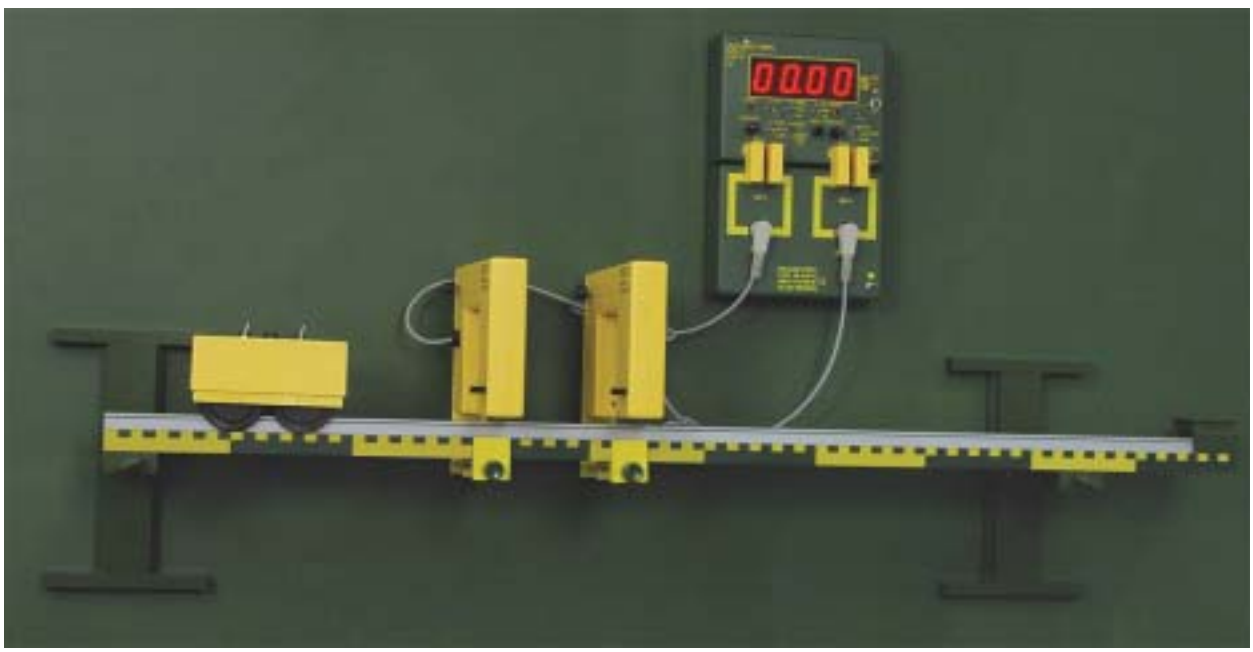
47 Motion

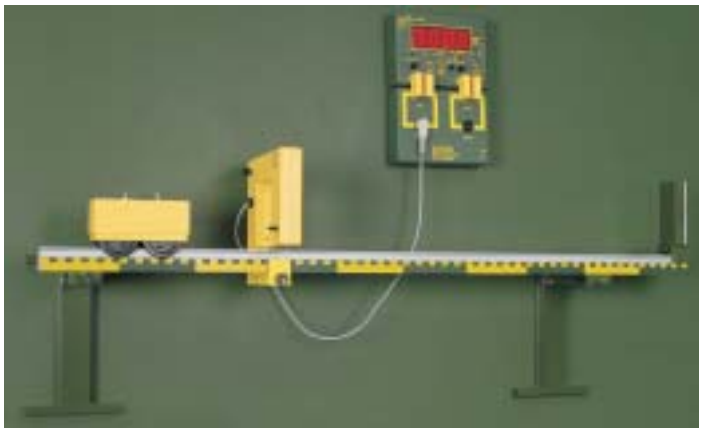


46 Roly poly

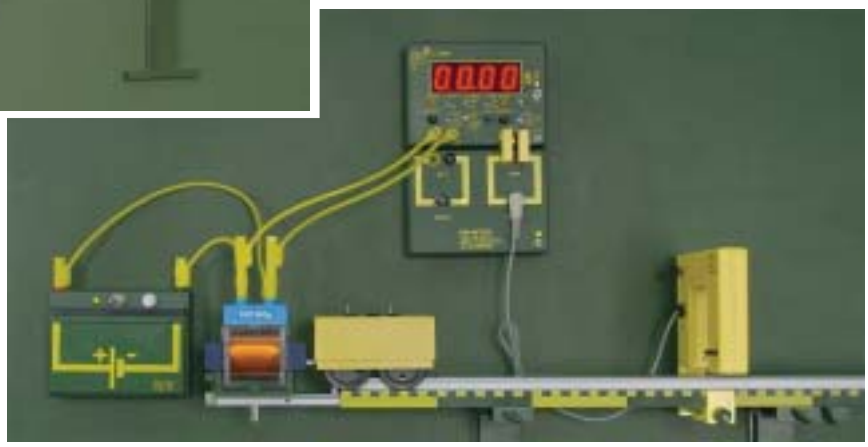
48
Uniform linear motion
eddy current device



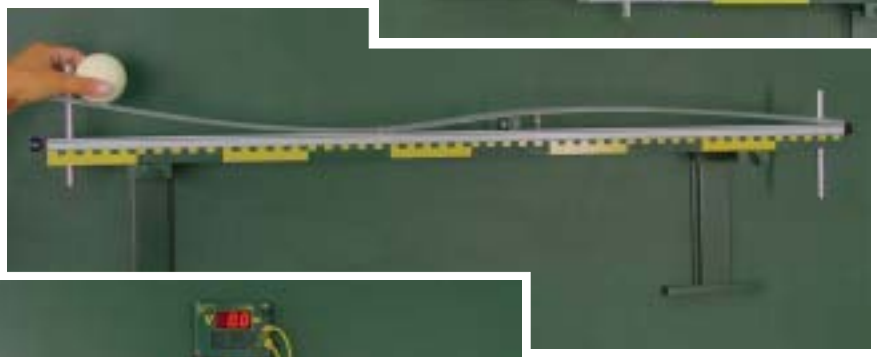
49 Uniform linear motion: same time same distance



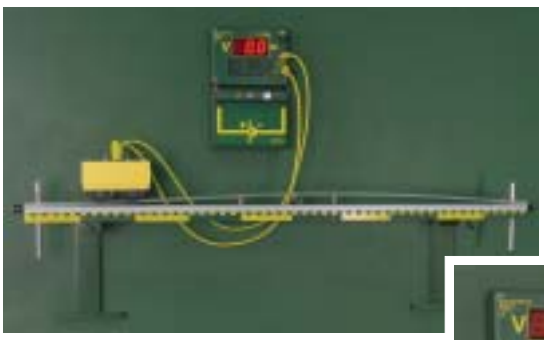
50
Velocity of a uniform linear movement



51
Law of time and distance applied to uniform linear motion

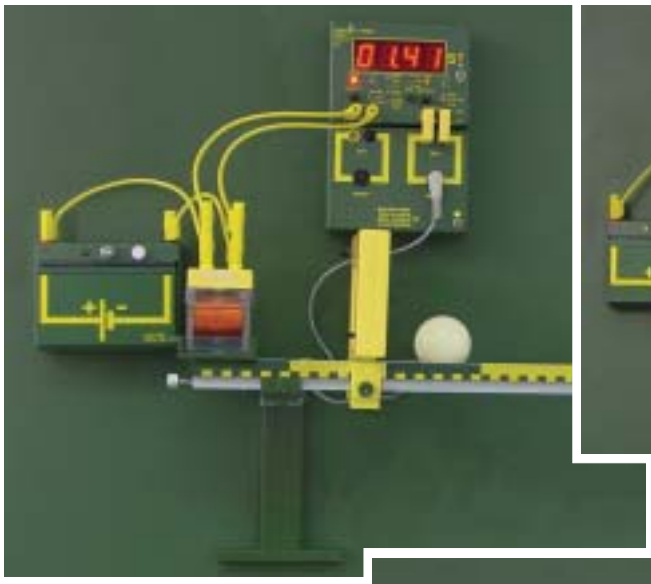


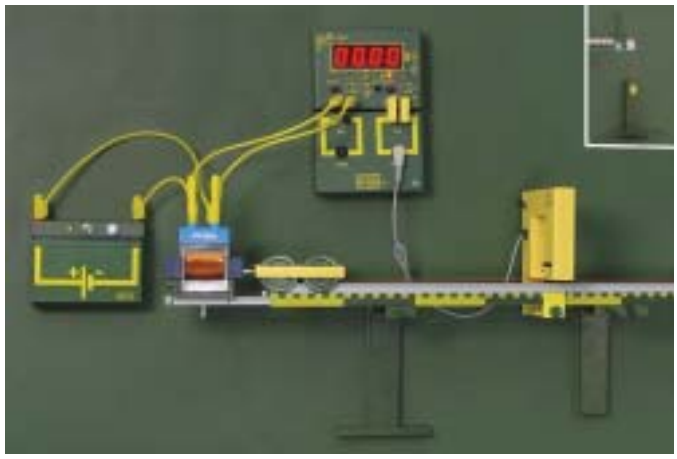
52
Non-uniform linear movement of a ball



53
Non-uniform motion up- and downhill

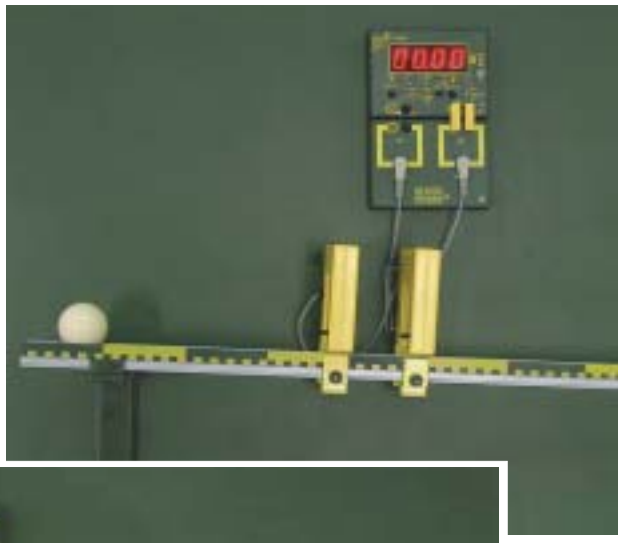
54
Non-uniform linear motion mean velocity





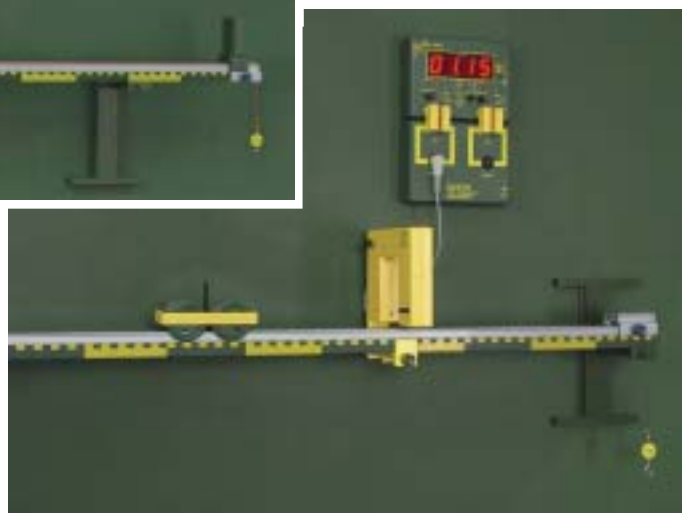
56 Law of time and distance applied to the accelerated uniform motion of a wagon

55 Law of time and distance applied to the accelerated uniform motion of a ball



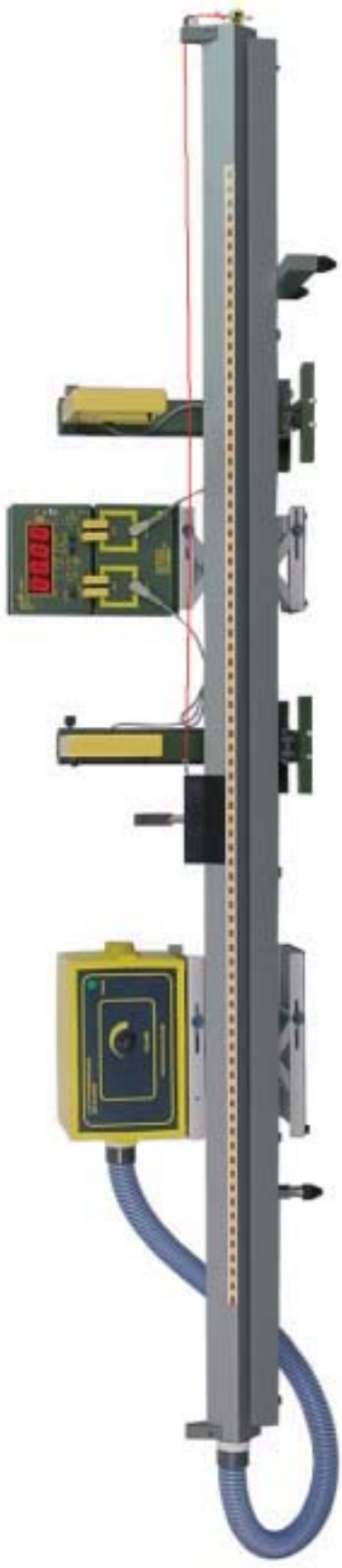
57 Law of time and acceleration applied to the accelerated uniform motion of a ball

58 Law of time and acceleration applied to the accelerated uniform motion of a wagon



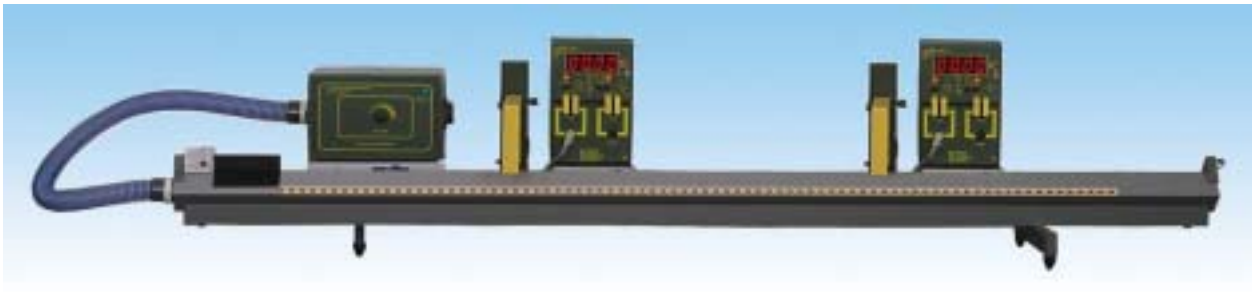
Newton's second law of motion **59**

Laws of Motion with the Air-Track

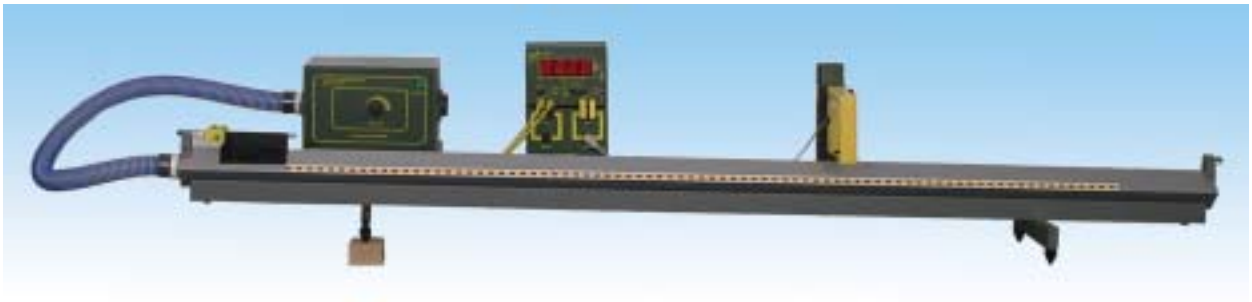


Air-Track, complete DM280-1F

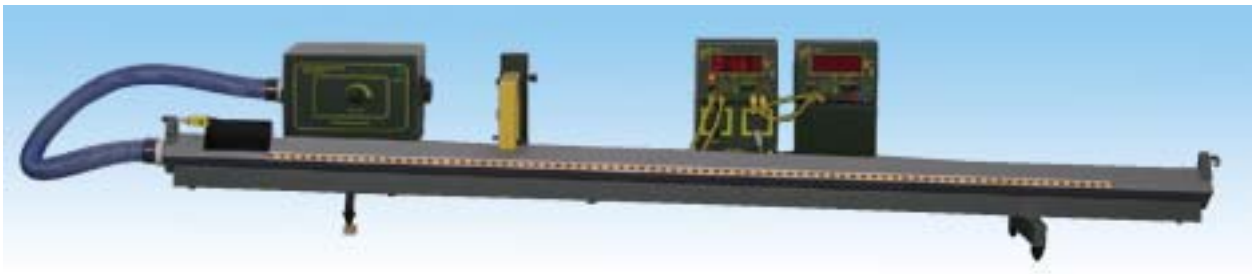
simple fast safe



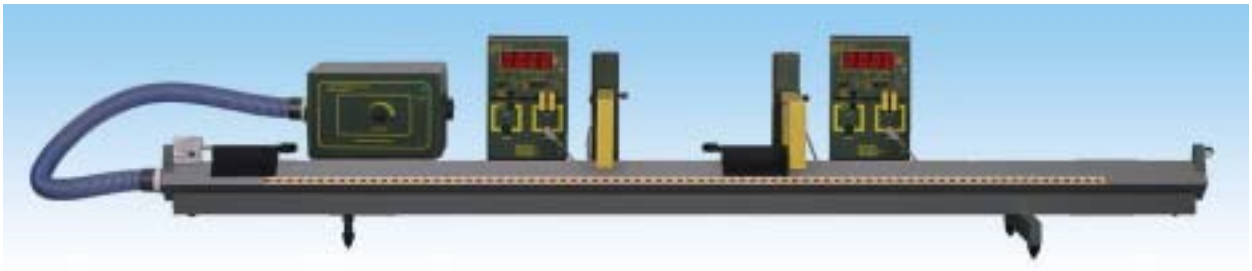
Motion under inertia - uniform slippage



Uniform acceleration and slippage (relationship of time and distance)

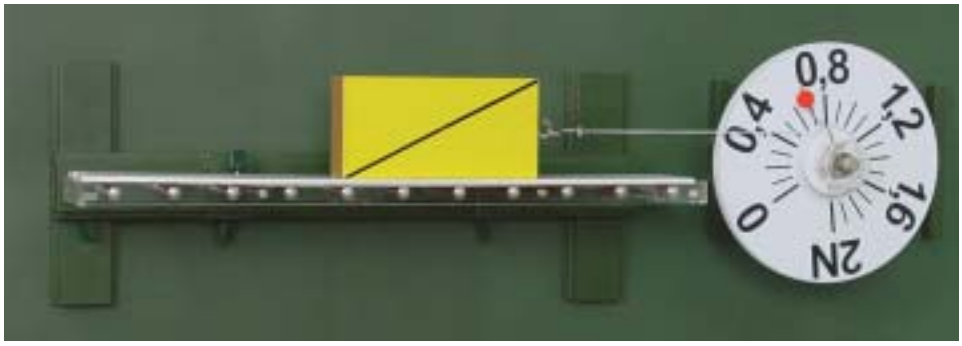


Uniform acceleration and slippage (relationship of time and acceleration)



Collision exchanges

60 Static friction

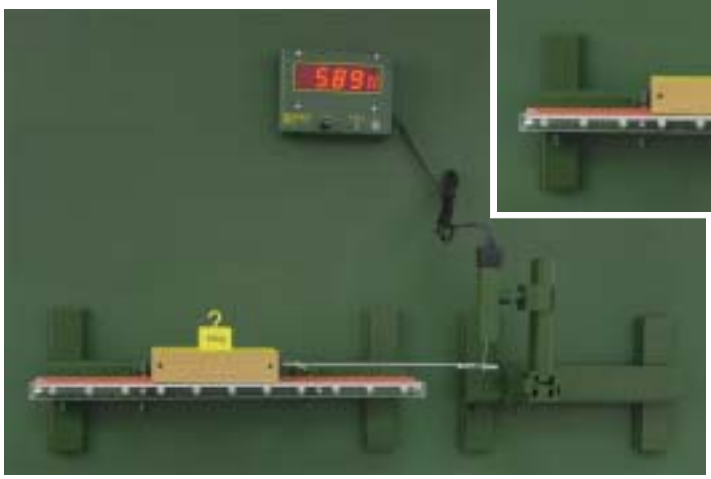


Dependence of the surface

Dependence of mass and surface

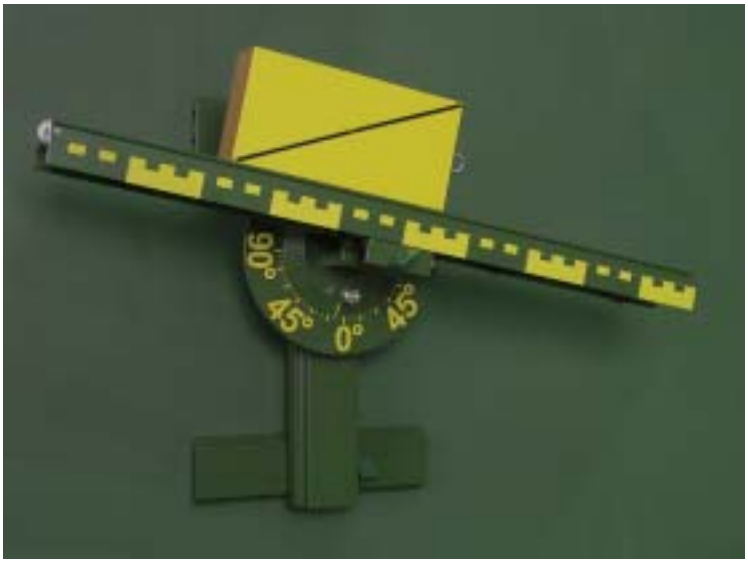
61 Sliding friction

Dependence of the surface

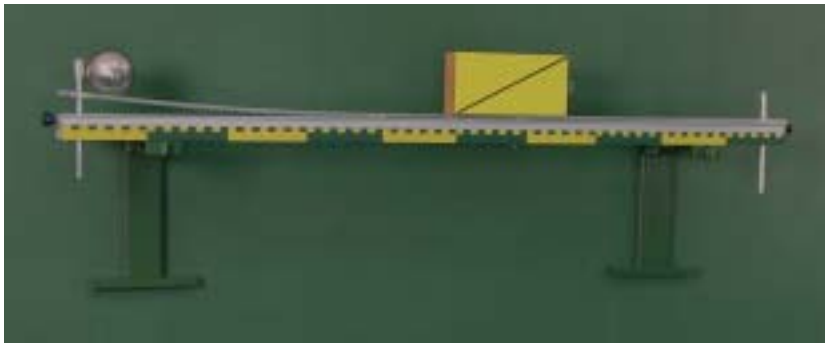


Dependence of mass and surface

62 Rolling friction



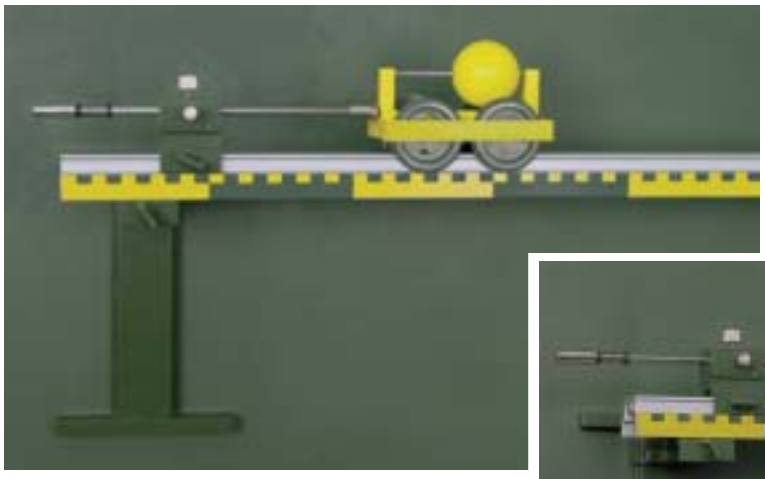
63 Determining the friction coefficient



64 Friction and types of surfaces

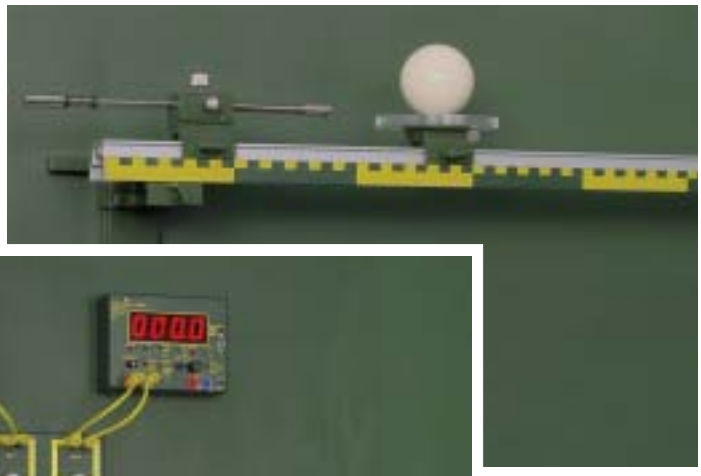
65 Inertia and mass

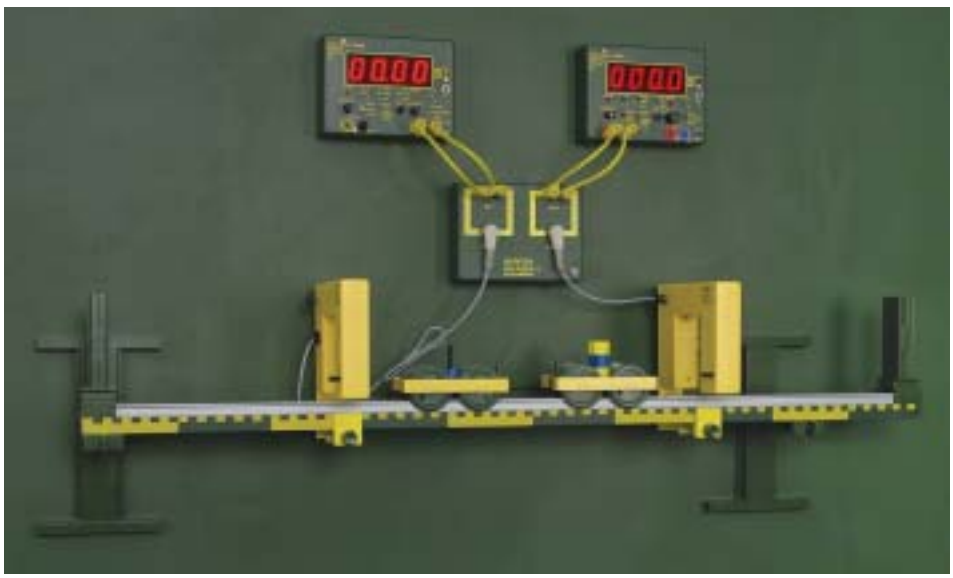
66 A body's inertia is independent of its mass



67 Mass moment of inertia

68 Inertia of a mass

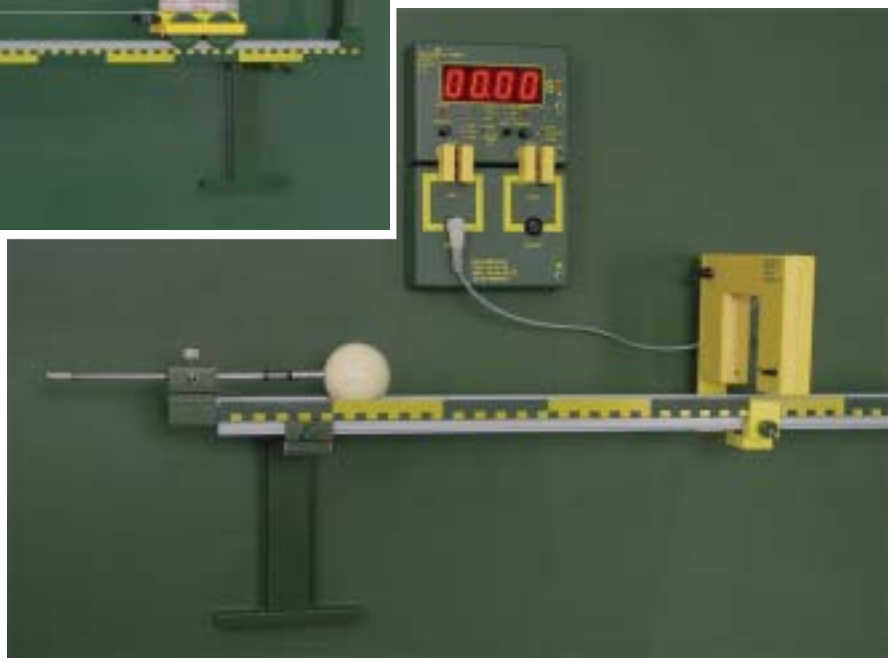


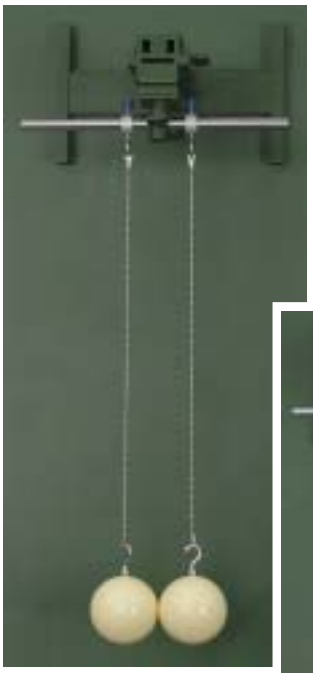


69
Interaction
and mass

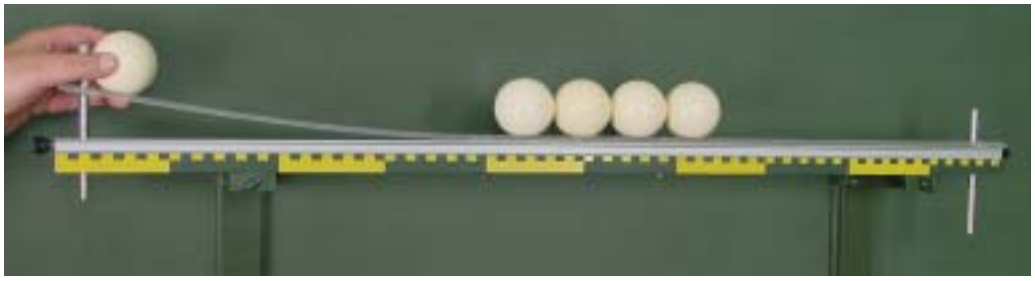
70 Interaction of opposing equal forces

71 Impulse

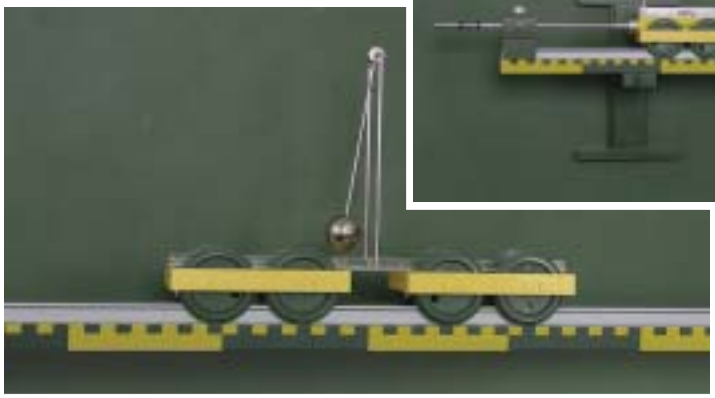


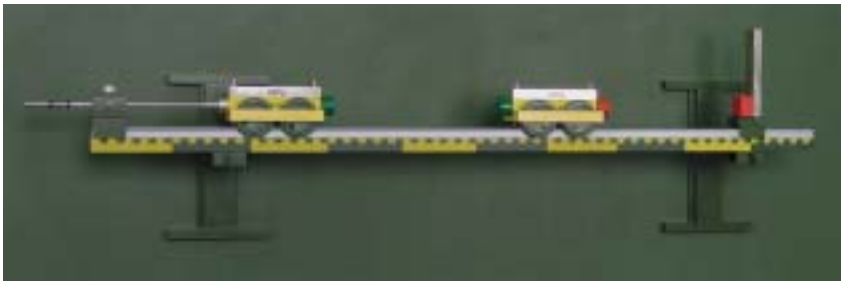


72 Momentum



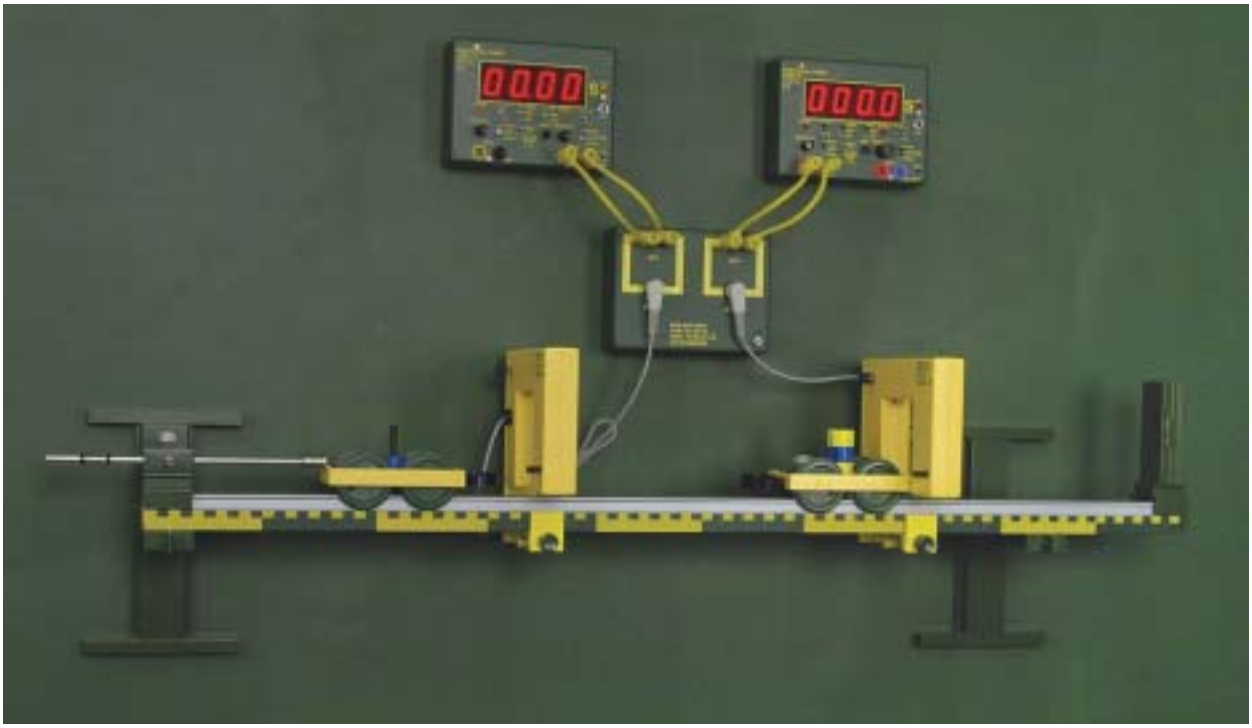
73 Law of interaction





74 Conserving momentum

75 Conserving momentum with equal masses



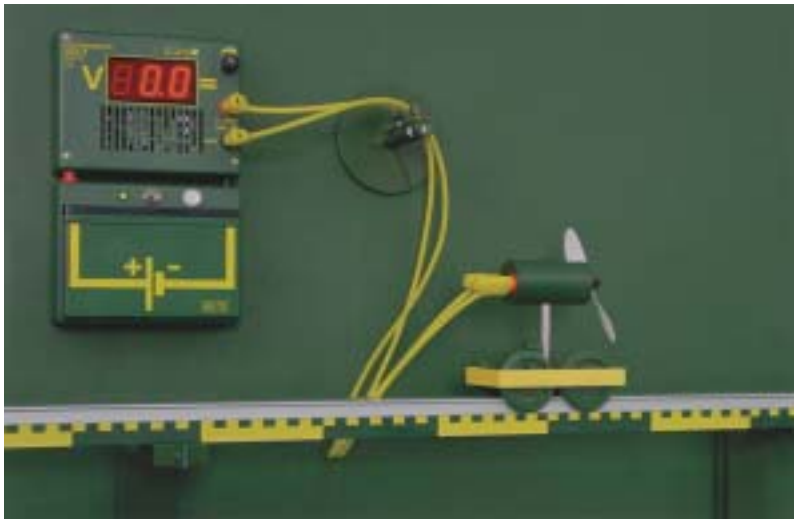
76 Conserving momentum with unequal masses

78 Repulsion - air outlet

77 Repulsion - water outlet

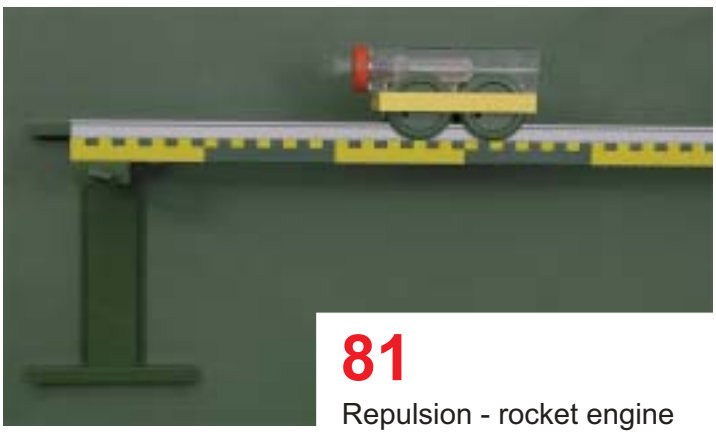
MECHANICS

80
Propeller drive



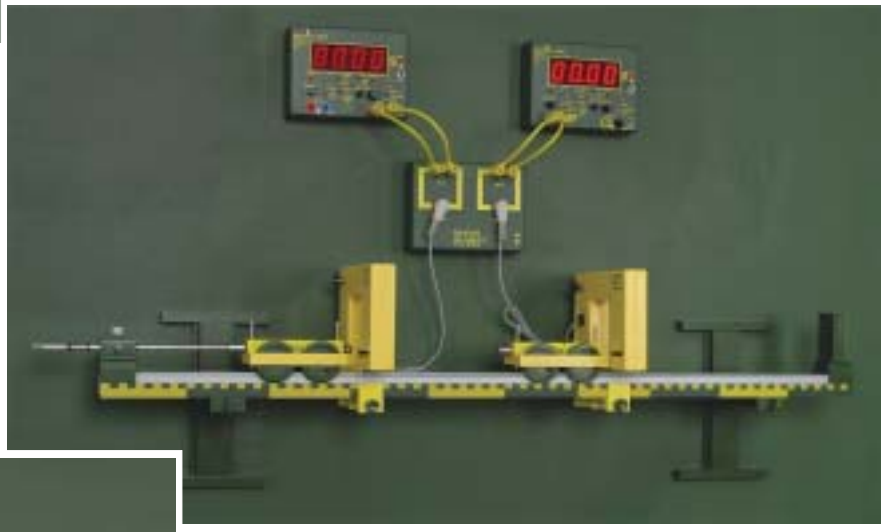
79 Segner waterwheel

82
Model of a rocket



81
Repulsion - rocket engine

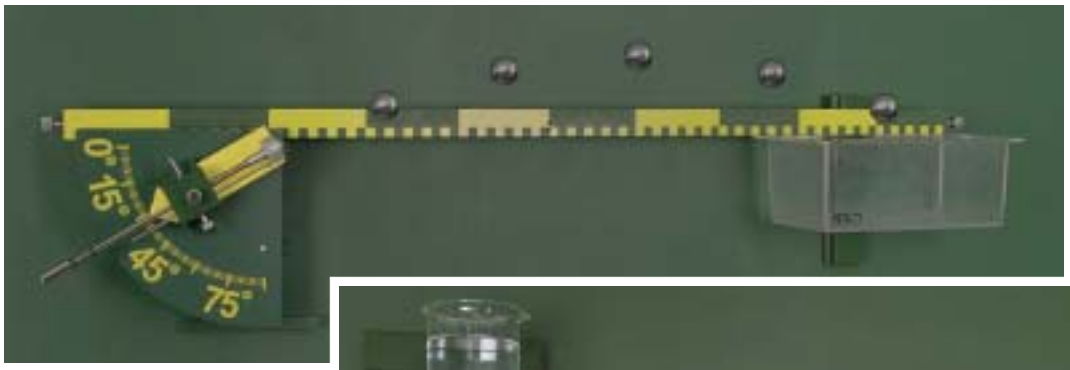
83
Elastic collision
with an obstacle



84 Non-elastic collision

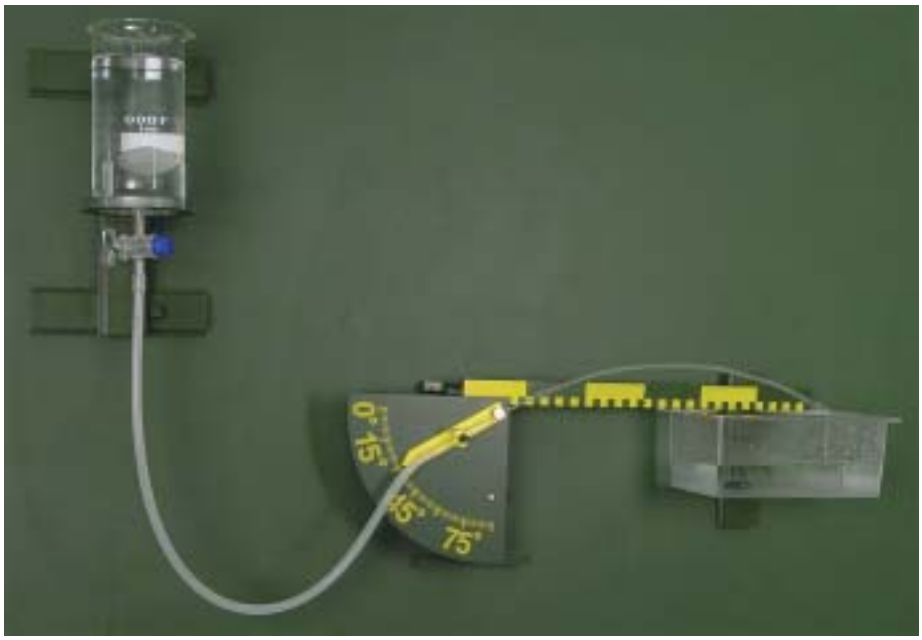
85 Free fall - gravity tube

86 Free fall - measuring
gravitational acceleration



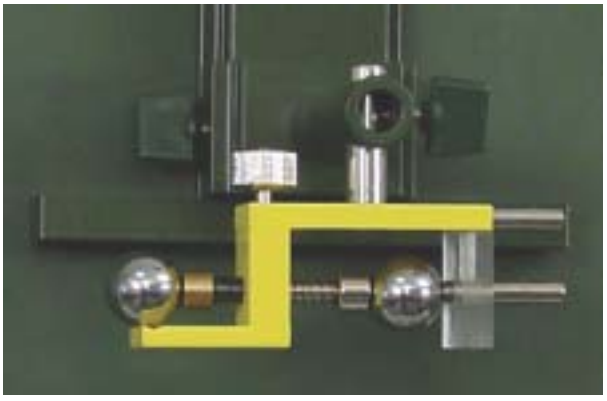
88

Horizontal and diagonal trajectories - shot-put



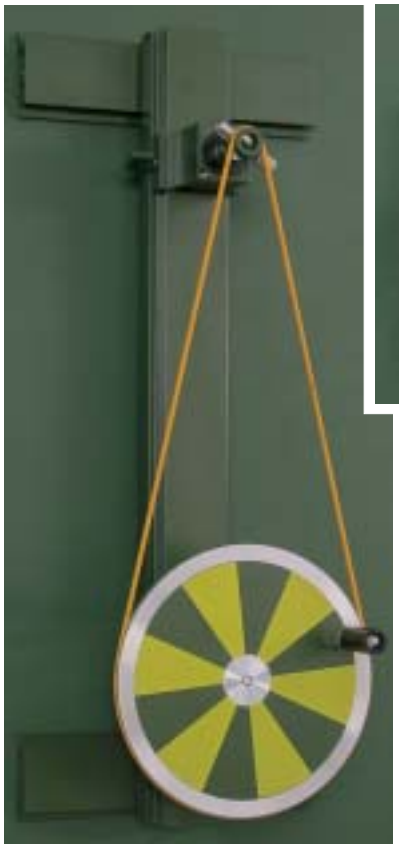
87

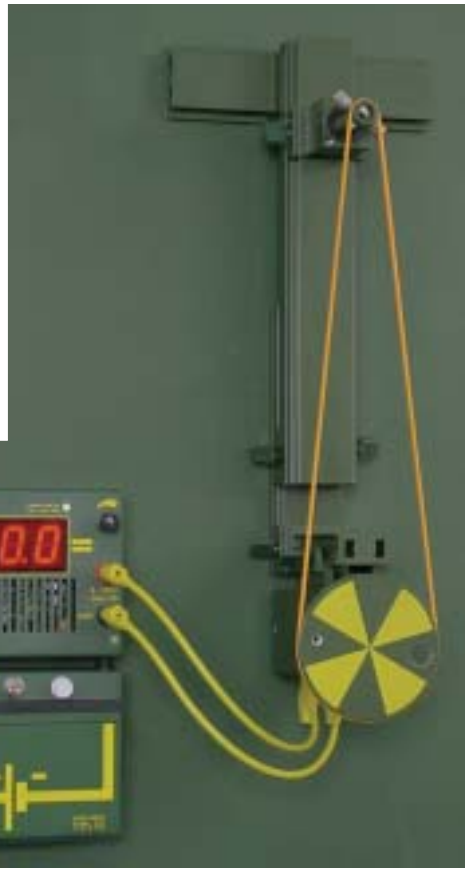
Horizontal and diagonal trajectories - stream of water



89

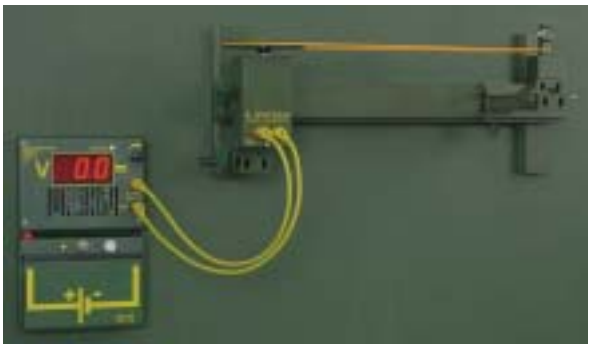
Principle of independence





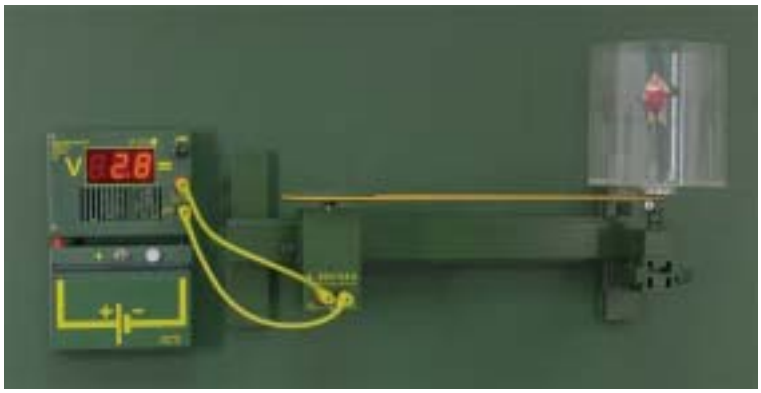
90

Variations on building a centrifuge (hand- and motor-driven)

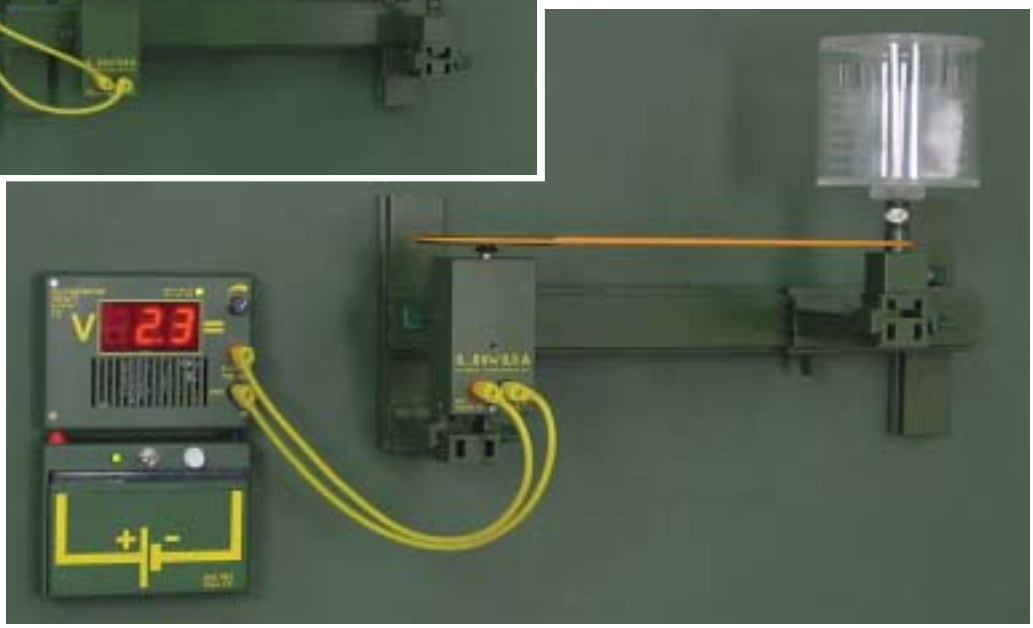


90

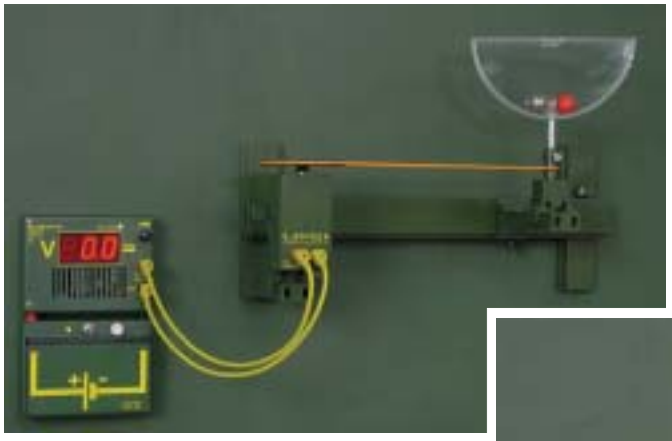
Variations on building a centrifuge (hand- and motor-driven)



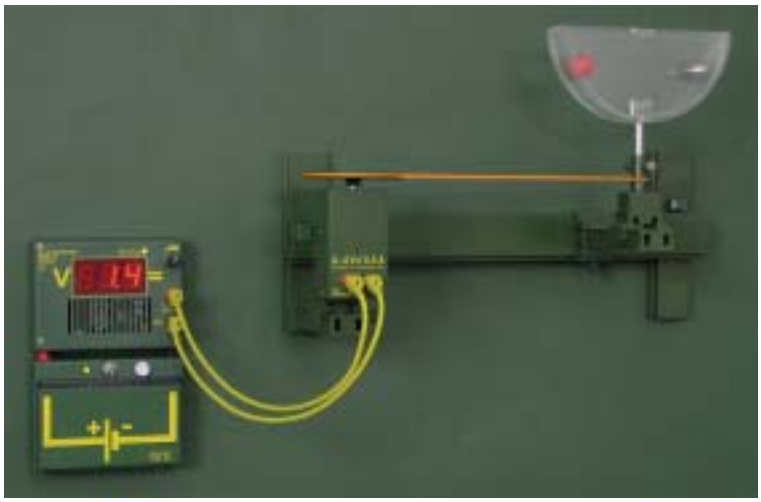
91 Centrifugal force - carousel



92
Centrifugal force -
centrifugal container



93
Centrifugal force -
floating ball

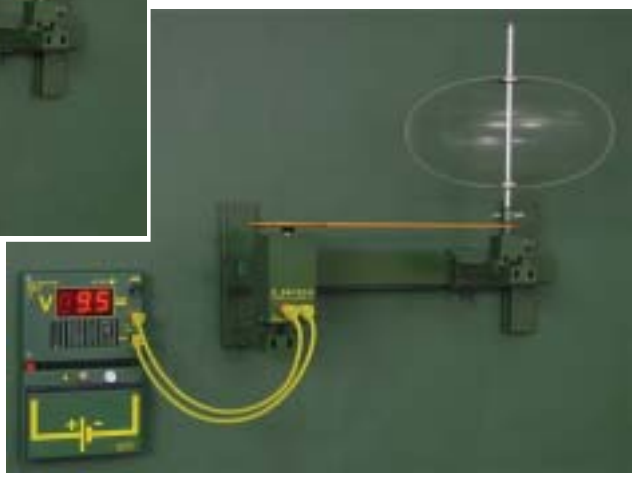


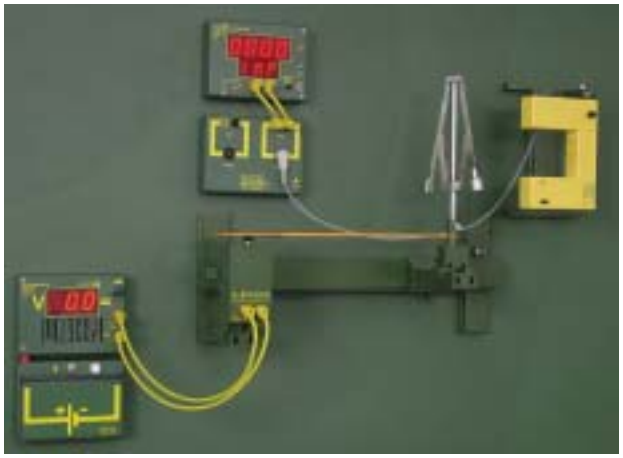
94

Centrifugal force - centrifuge

95

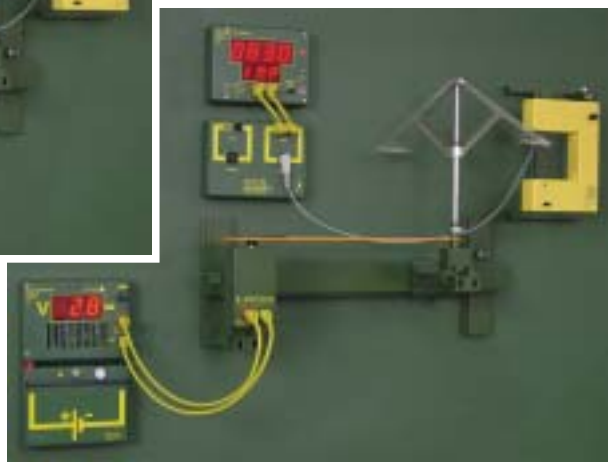
Centrifugal force -
the earth´s oblateness

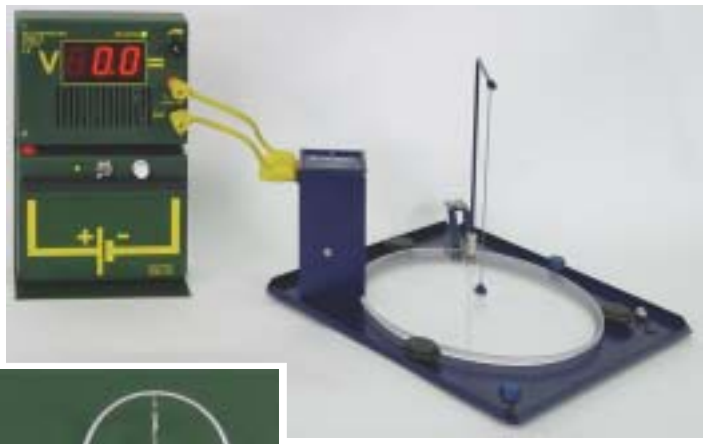




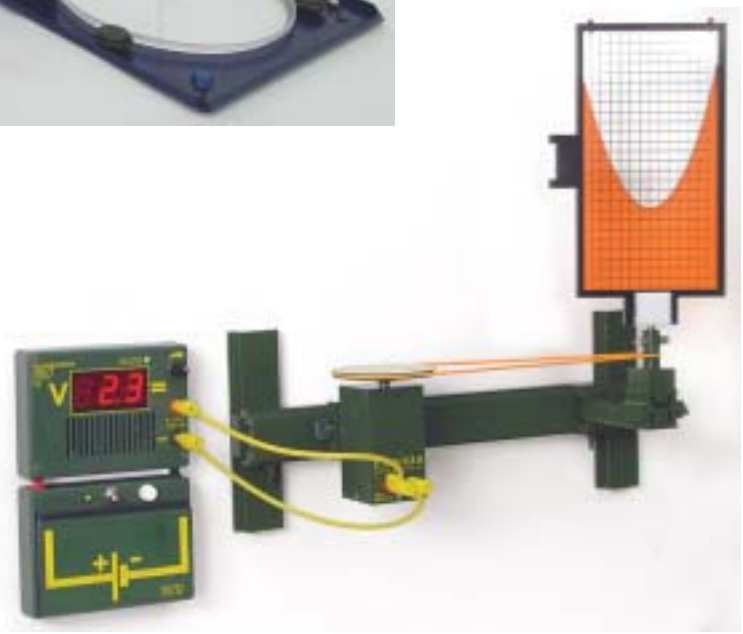
96

Centrifugal regulator





100
Foucault´s pendulum - overhead projection



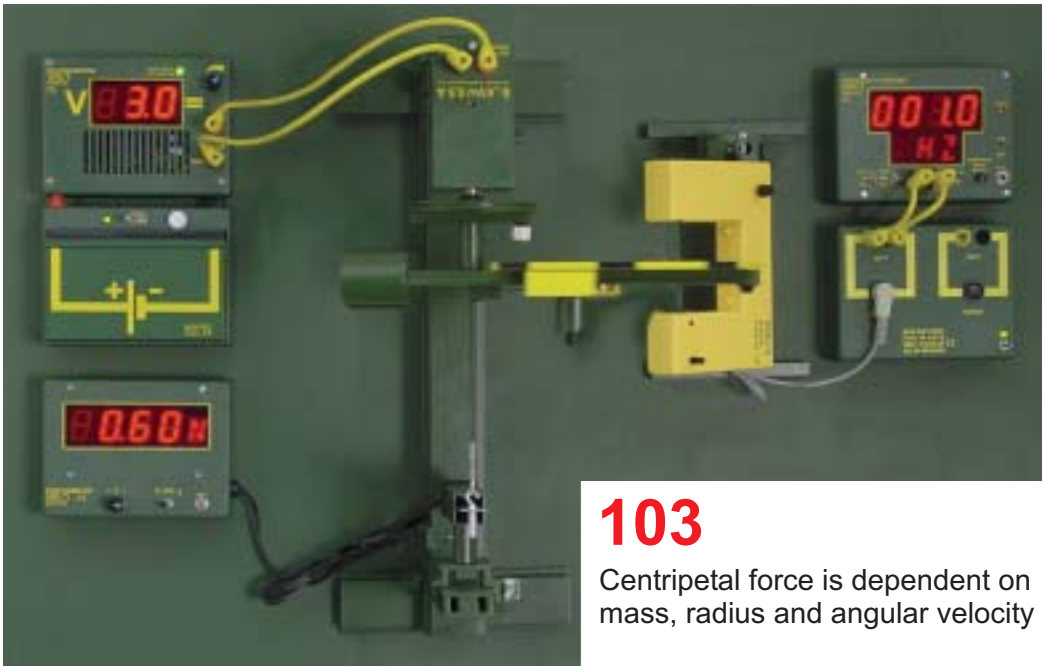
97 Rotating liquids

99 Rotating pendulum

98
Centrifugal force - a paradox

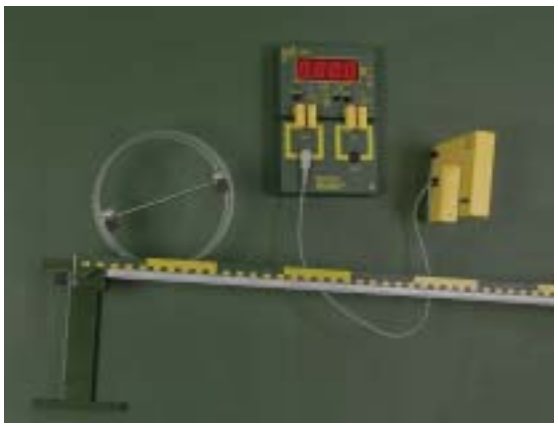
102 Centripetal force

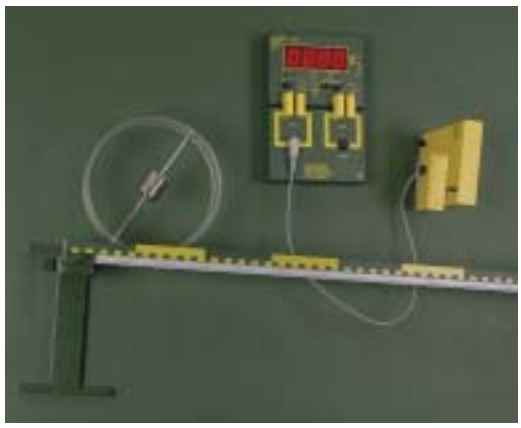
101 Centrifugal force



103

Centripetal force is dependent on mass, radius and angular velocity





104 Moment of inertia and distribution of mass

105
Conserving angular momentum

106 Bicycle as a gyroscope

MECHANICS

107

Precession movement
in a gyroscope

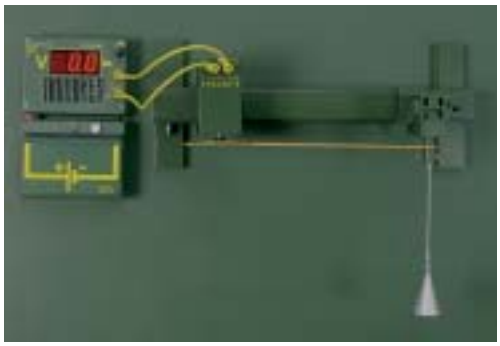
108

Gyroscope

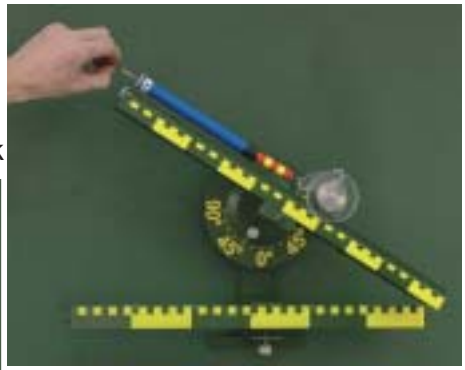
109 Gyrocompass

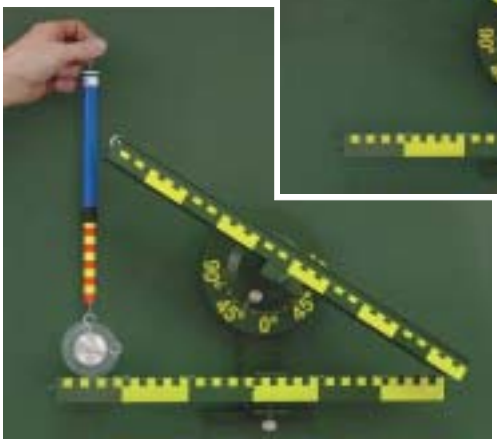
simple fast safe

110
Bodies rotating symmetrically

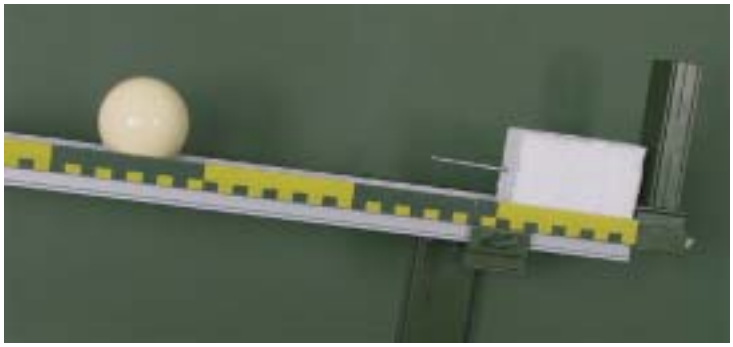


111
Lifting work





112 Acceleration work

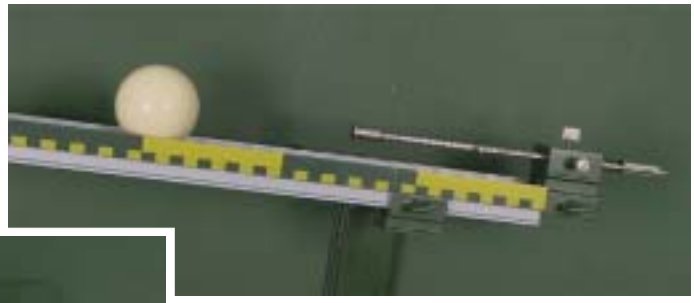


113 Potential energy

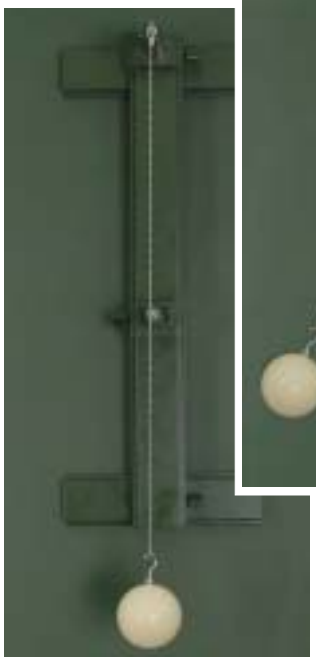
114
Potential energy - forming

115 Potential and tensional energy

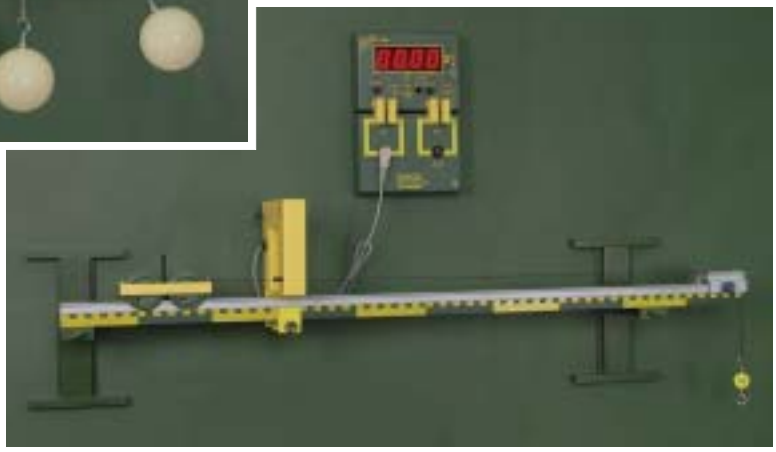
116 Rotational energy



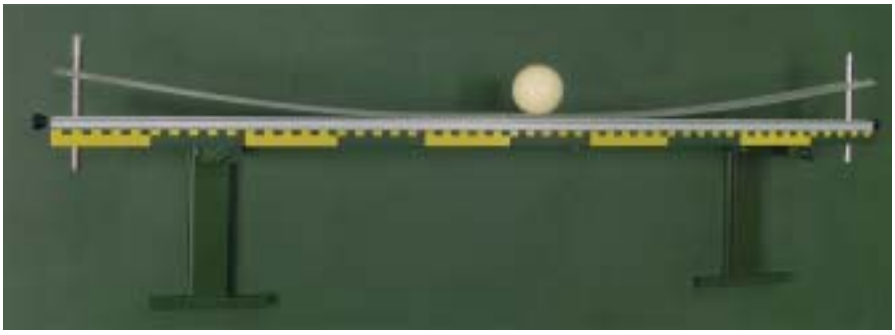
117 Conserving energy



118 Conserving energy in a pendulum

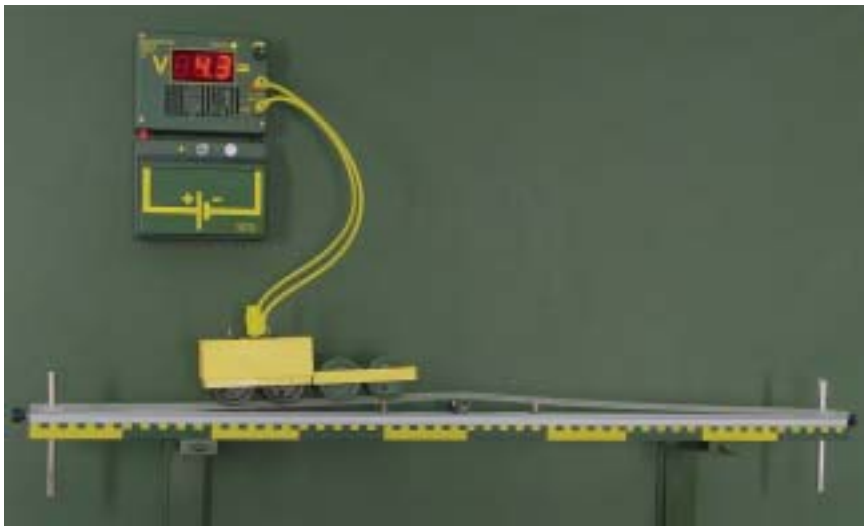


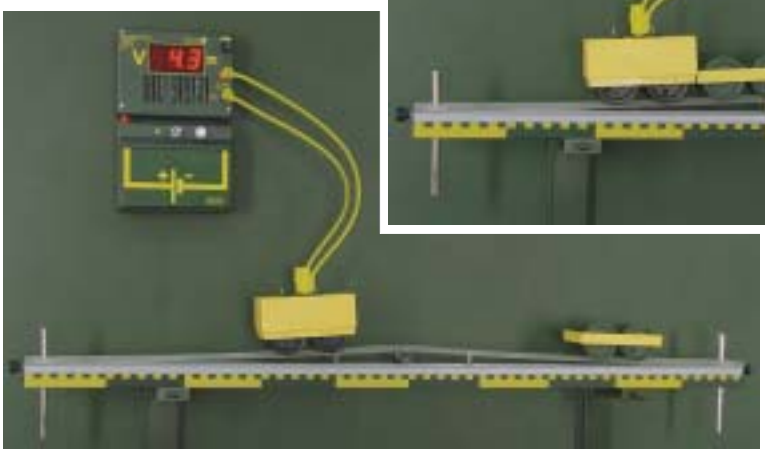
119 Kinetic energy

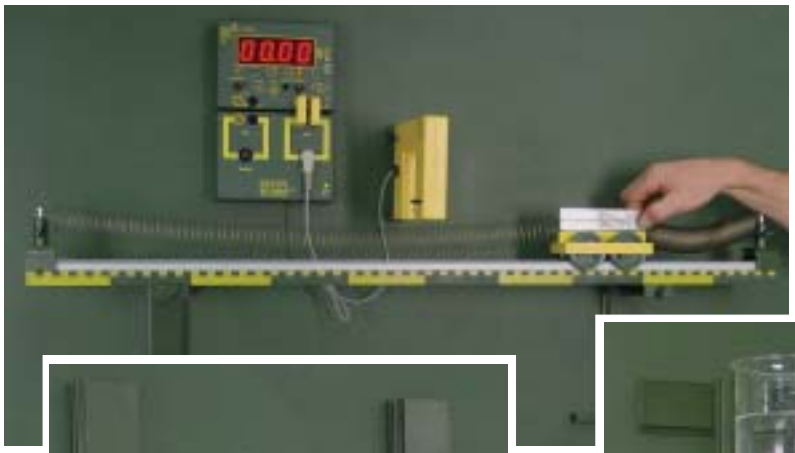


120

Potential energy -
kinetic energy



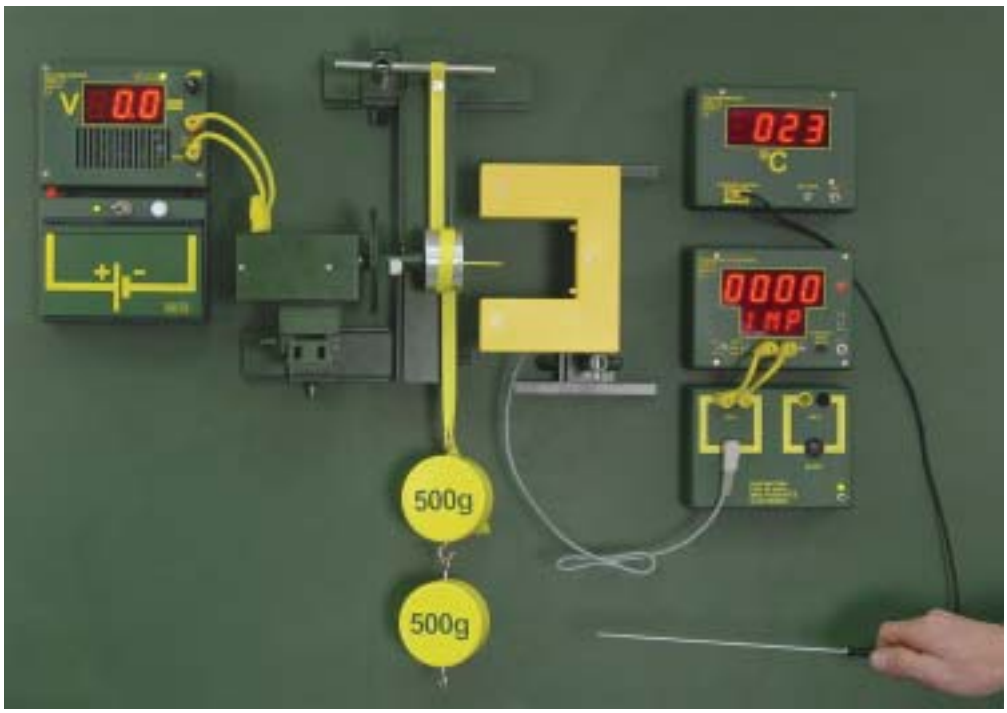




121
Tensional energy -
kinetic energy

122
Artesian wells

123 Maxwell´s wheel

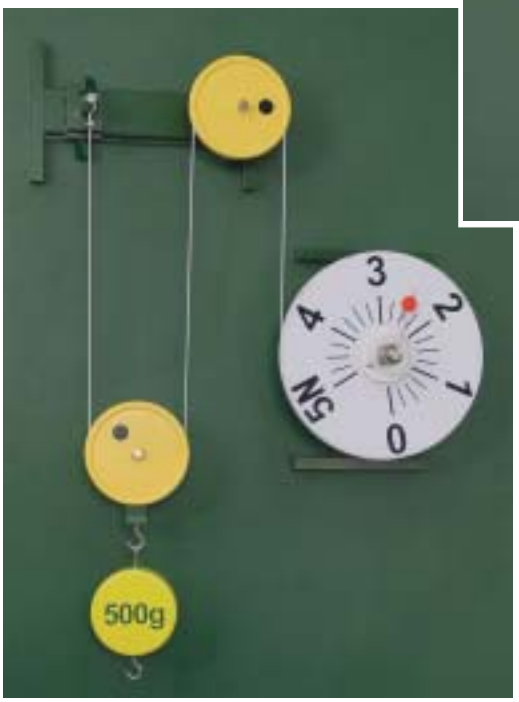


124
Friction and
heat energy

simple fast safe

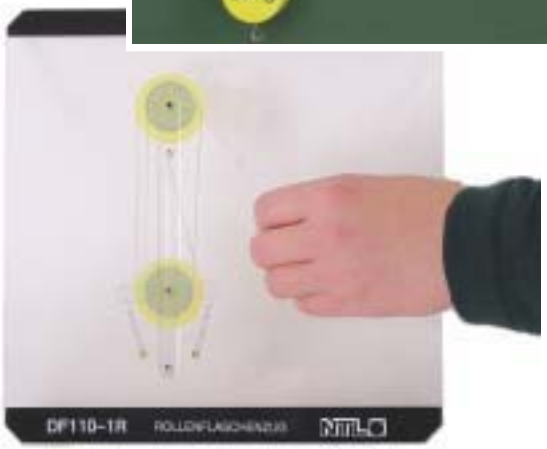
125
Fixed pulley

126
Moving pulley



127
Simple block and tackle

128 Block and tackle with four pulleys



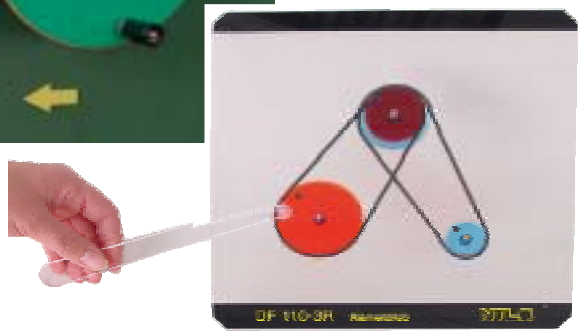
129 Parallel block and tackle with four pulleys

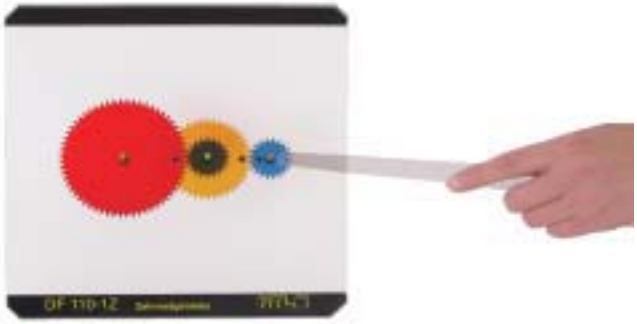
130 Wheel and axle

simple fast safe

131

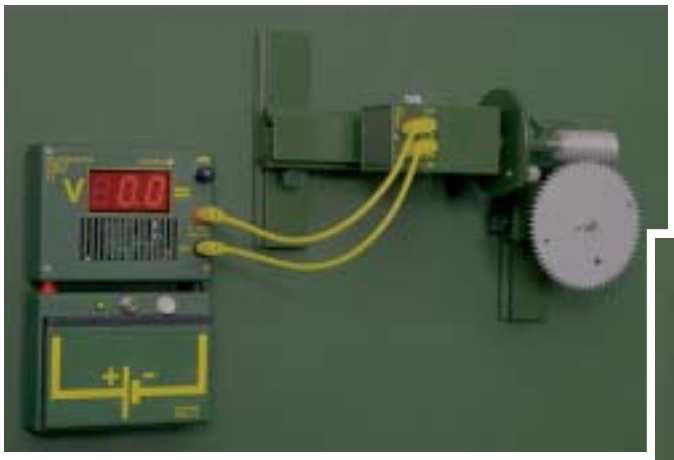
Belt drive



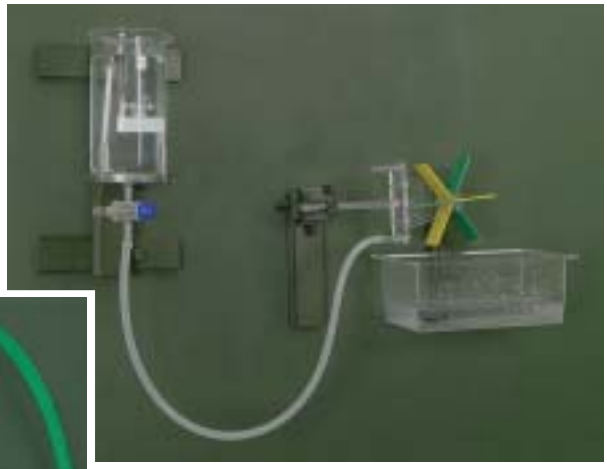


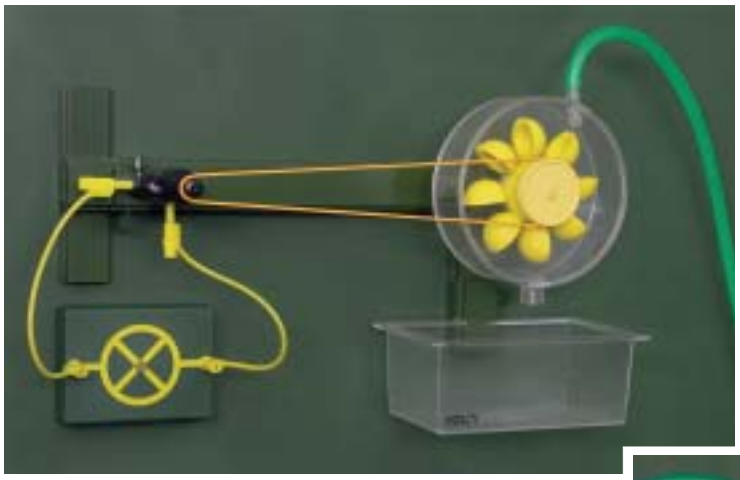
132 Sprocket drive

simple fast safe



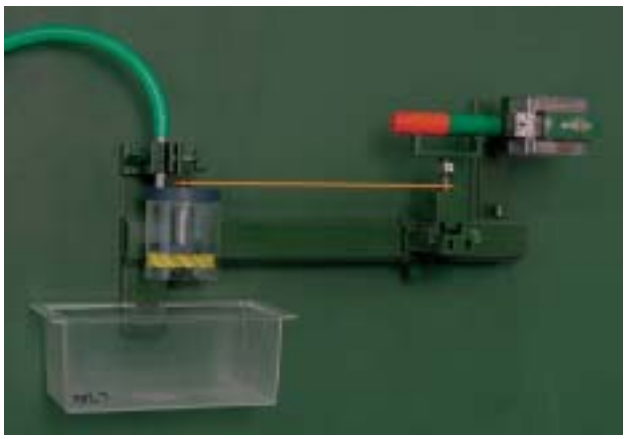
133 Worm drive





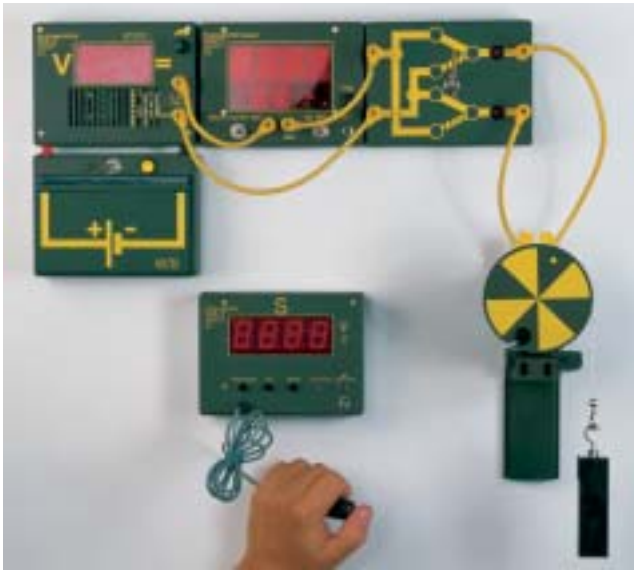
134 Waterwheel

135 Pelton turbine



136 Kaplan turbine

137 Lifting work and power - windmill

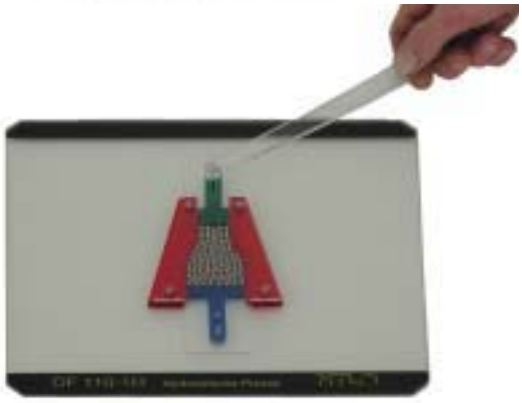


138 Lufting work and power - motor

139 Demonstrating pressure - the bar

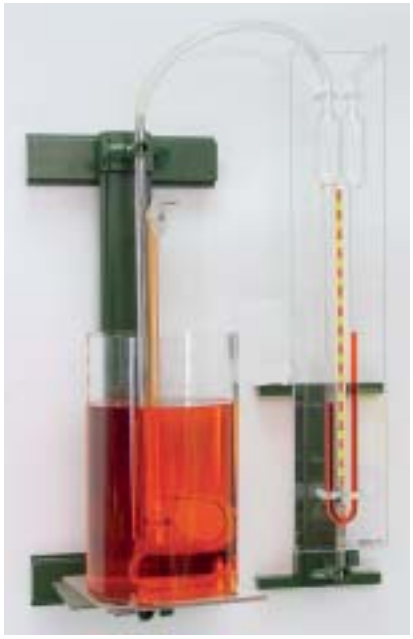
140 Deformation depends on area

141 Pressure on different surfaces



142 Hydraulic press

143 Measuring hydrostatic pressure using immersion sensors of different shapes



144 Measuring hydrostatic pressure using Hartl's apparatus

145 Upward pressure

146 A hydrostatic paradox - ground pressure device

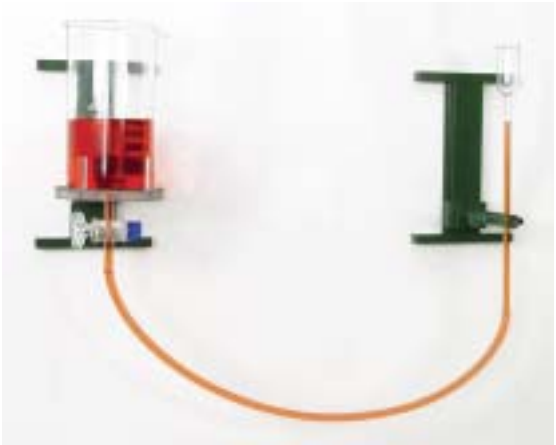
148 Velocity of outflow

147
Distribution of pressure in liquids

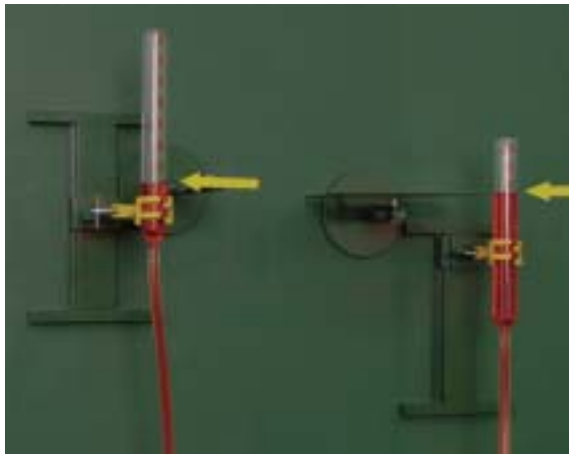
149
Lateral pressure and velocity of outflow

150 Communicating vessels

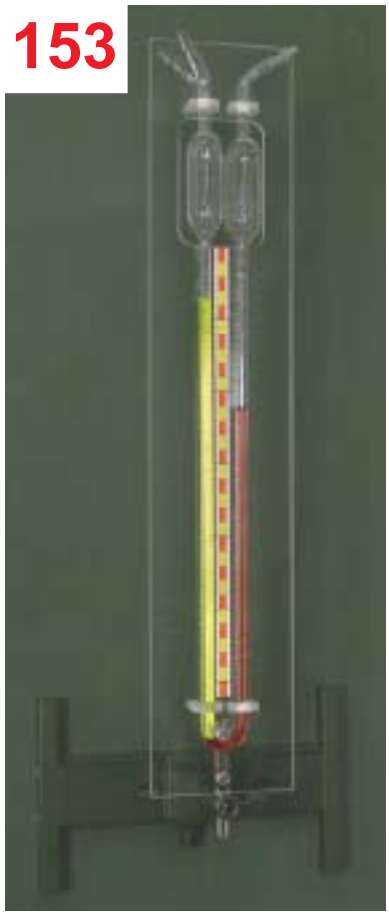
151
Watering can



152
Level measurement - hose leveling instrument



153



Comparing the density of immiscible liquids using a u-shaped tube

154 Pressure is dependent on area

155 Pressure change by density change

156

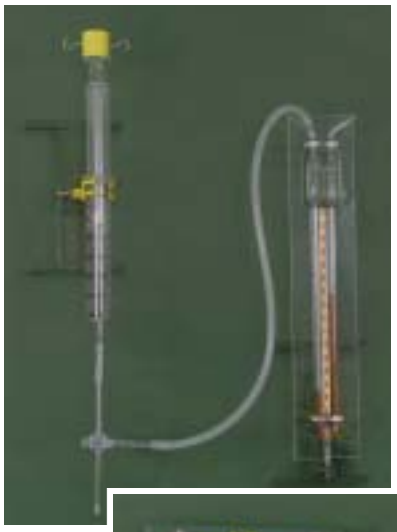
Measuring pressure change by density change

157

Pressure change by
temperature change

158

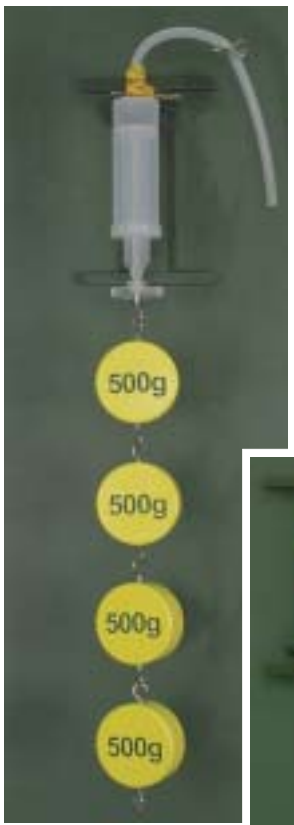
Pressure increase temperature increase



159
Liquid manometer

160
Piston manometer

161
Boyle´s law



162
Demonstrating air pressure

163
Over- and underpressure

164 Measuring air pressure - model barometer

165 Measuring the vacuum in a water-jet pump

166 Effects of air pressure

166

Effects of air pressure

166

Effects of air pressure

167

Determining outside air pressure

simple fast safe

168 Measuring air pressure in a balloon

169
Siphon

170
Vacuum pump

171
Pressure pum

172 Buoyancy in a liquid

173
Measuring buoyancy

174
Buoyancy determining forces

175 Buoyancy of bodies with different densities

176 Floating-hovering-sinking

177
Areometer

178
Model of a submarine

179
Floating
Styrofoam ball

180

Archimedes's principle

181 Buoyancy in air

182

Elastic –
Plastic–
Brittle

183

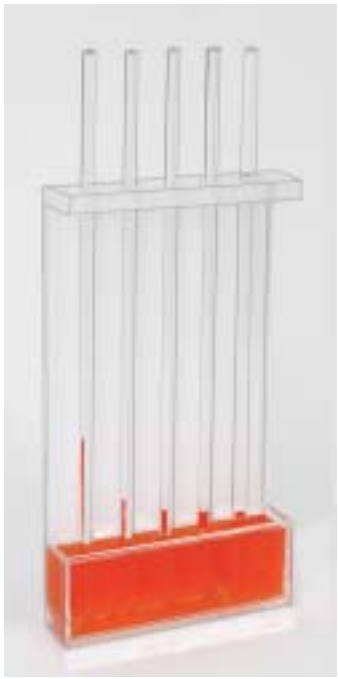
Cohesion and adhesion

185

Capillary action
surface tension

184

Capillary attraction

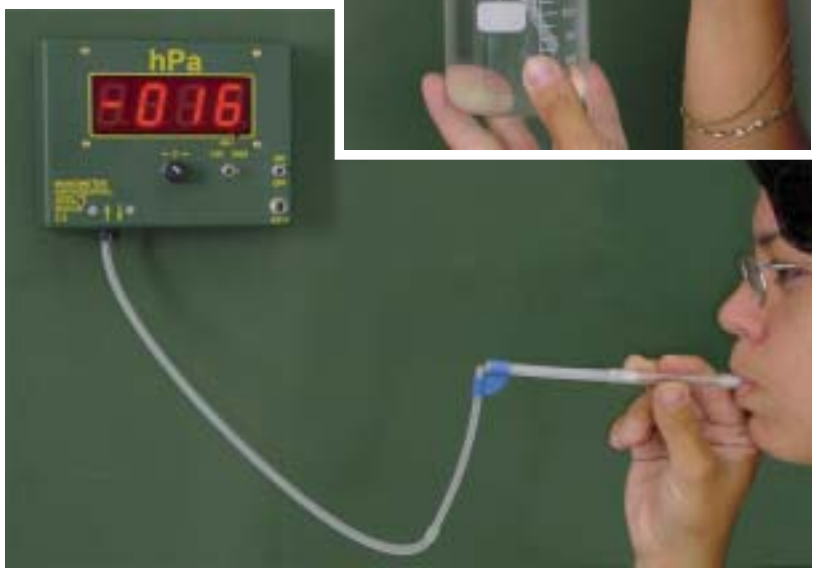


MECHANICS

186 Measuring surface tension of liquids

187 Plane soap film

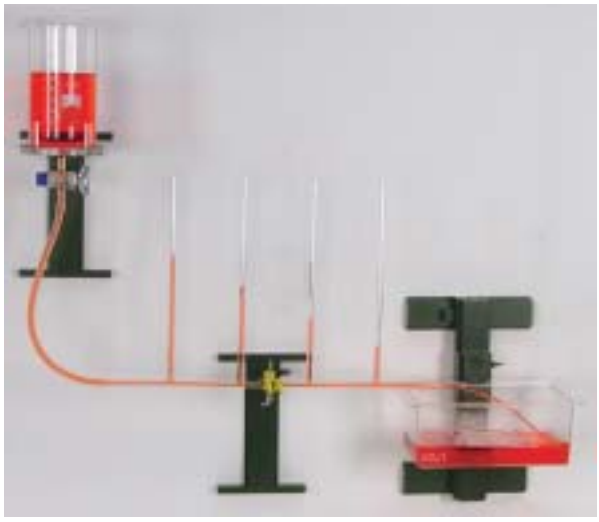
189 Vaporizer



188 Osmotic pressure

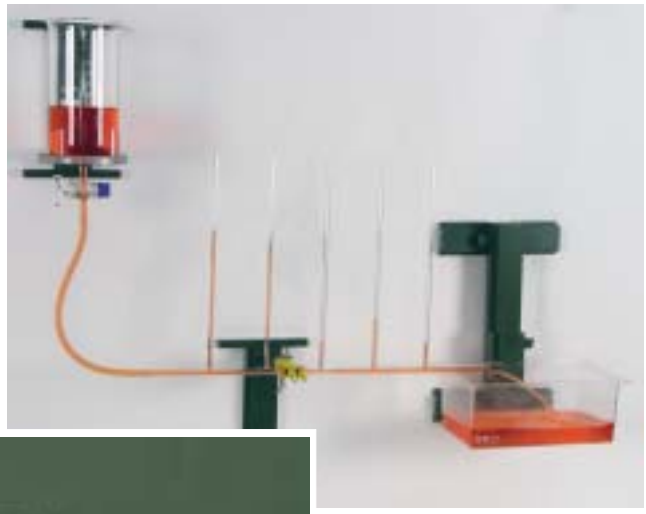
190 Measuring the vacuum in a vaporizer

simple fast safe



191

Pressure distribution in flowing liquids
tubes of a constant diameter



192

Pressure distribution in flowing liquids
tubes of varying diameters

193

Model of an
anemometer

194

Measuring flow velocity

195 Dynamic pressure of an air current

196

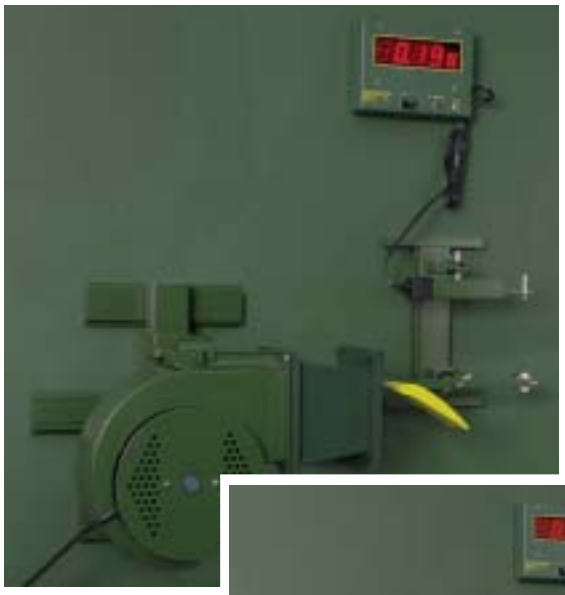
Flow pressure - Venturi tube

197

An aerodynamic paradox

198

Buoyancy in air currents



Buoyancy of air foils with a flat and steep angle of incidence

199

200

Drag in air foils

201 Distribution of pressure on an air foil

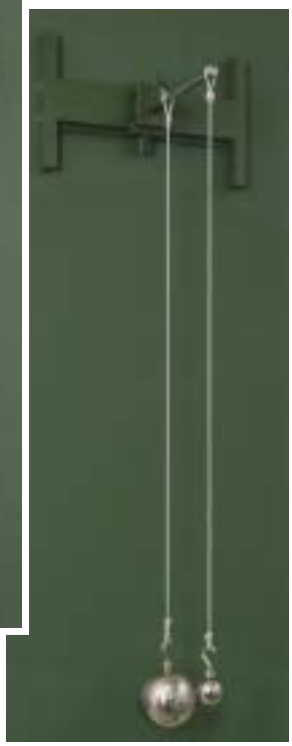
202

Air resistance and the shapes of bodies

203 Air resistance and the diameters of bodies

204

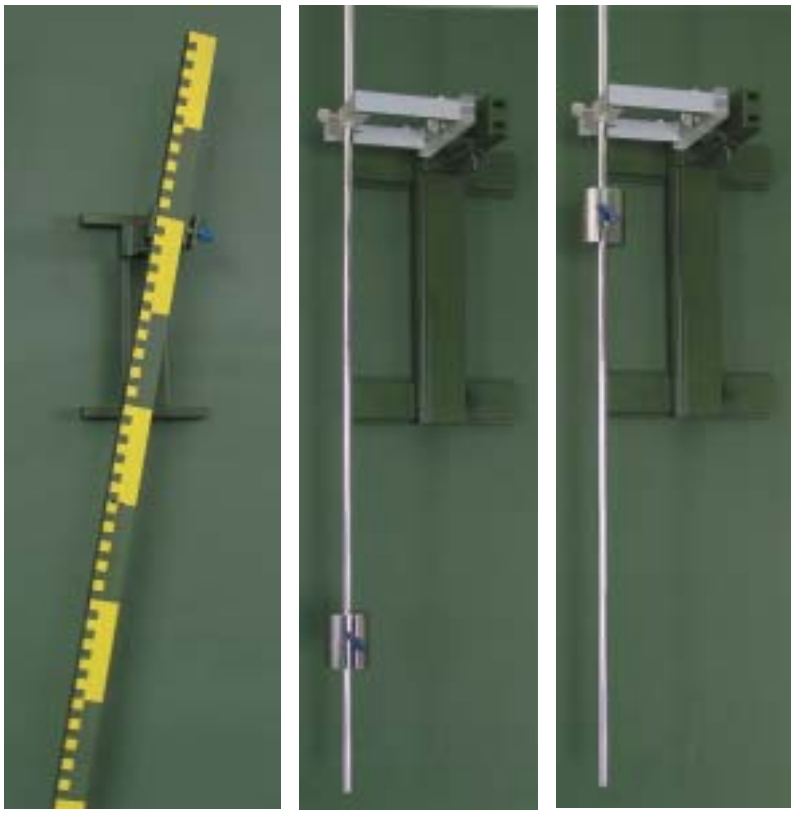
Air resistance and bodies' surface types



205
String pendulum

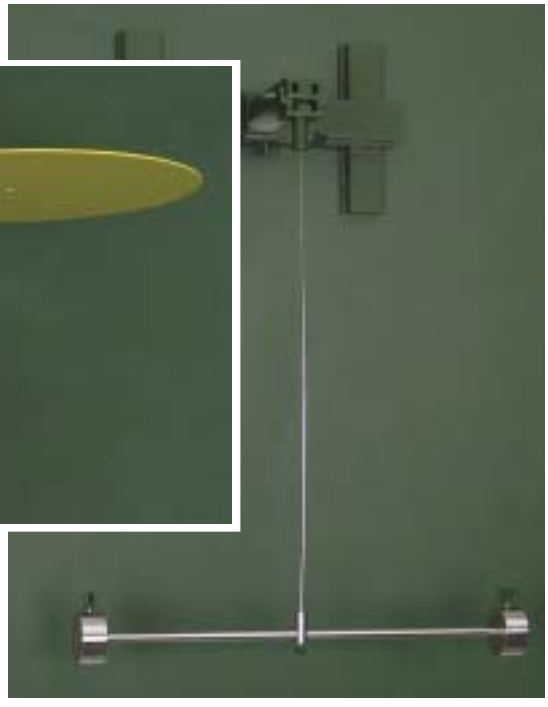
206 Spring pendulum

207 Determining the elasticity constant



208 Reversion pendulum

209 Steiner's law



210 Torsion pendulum: determining the moment of inertia

211
Coupled pendulum

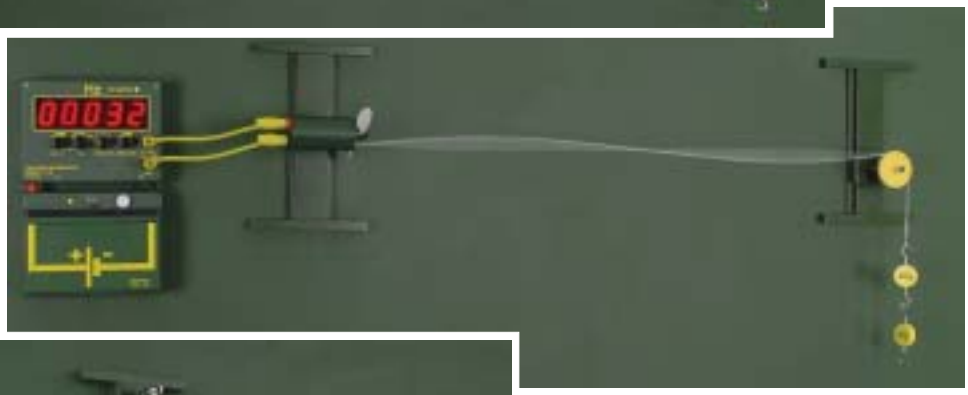
213
Harmonic torsional vibration

214
Moment of inertia and duration of torsional vibration

212
Resonance of a spring pendulum

215

Moment of inertia of a hollow and solid body

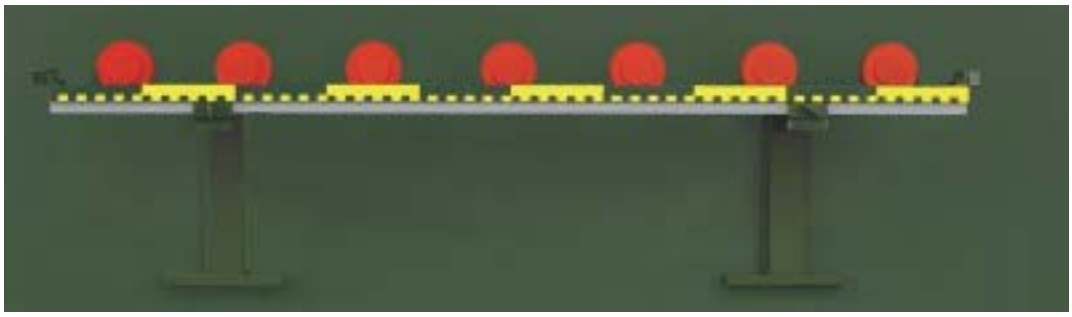


216

Standing transverse waves

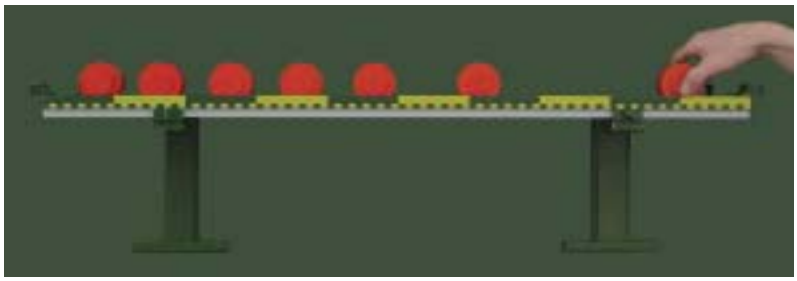
217

Standing longitudinal waves



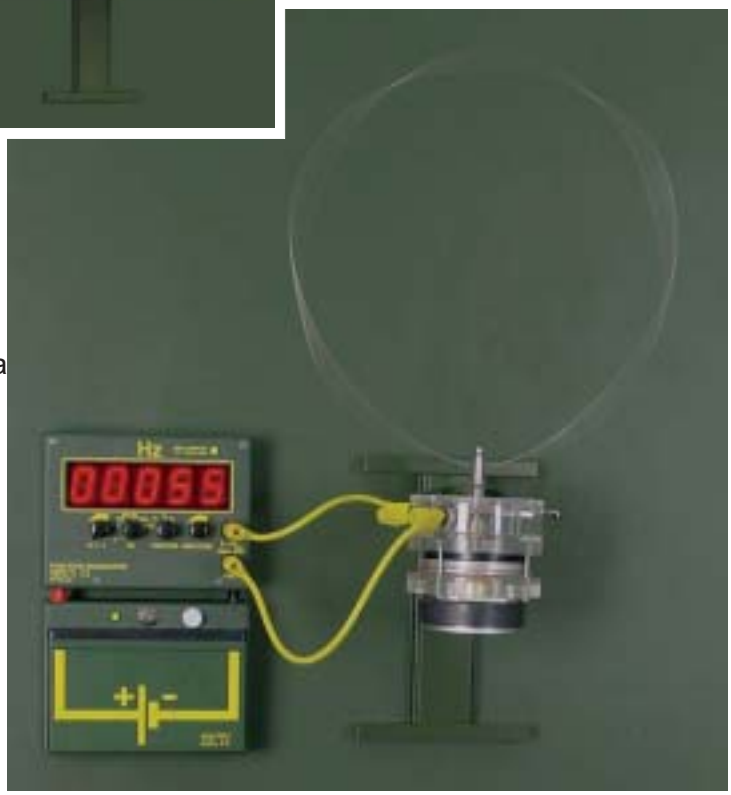
218

Diffusion of longitudinal waves: magnetic wave device



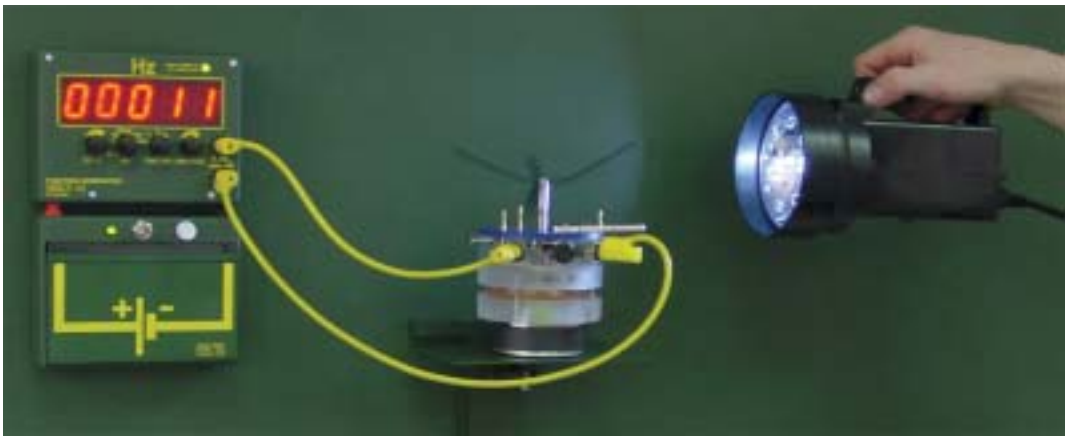
219

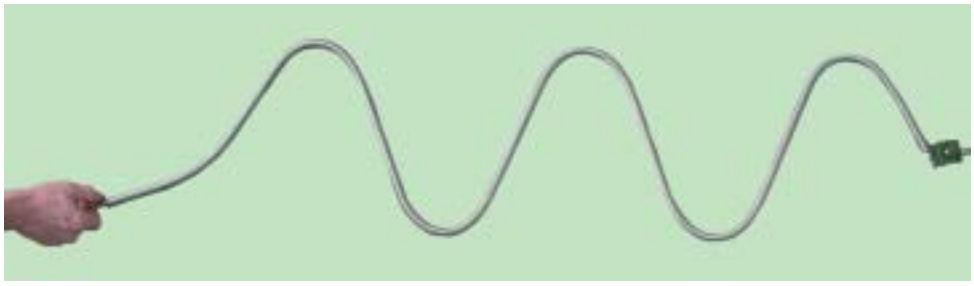
Standing concentric wa



220

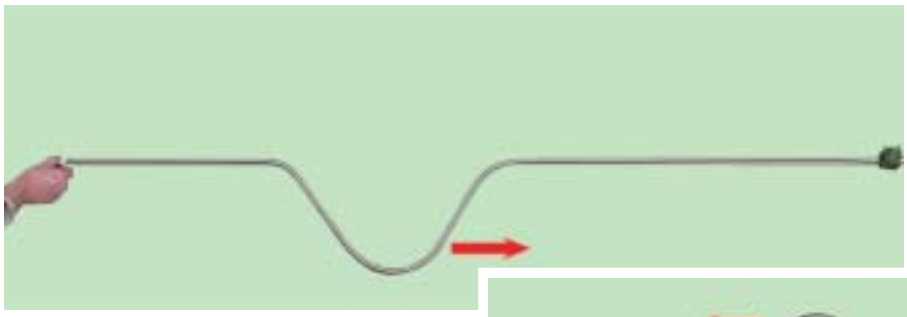
Vibrating reed frequency meter





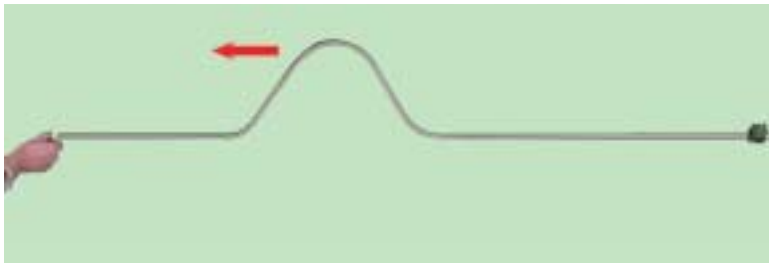
221

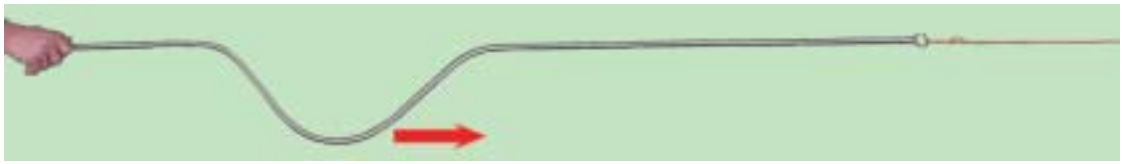
Standing waves
with a fixed end

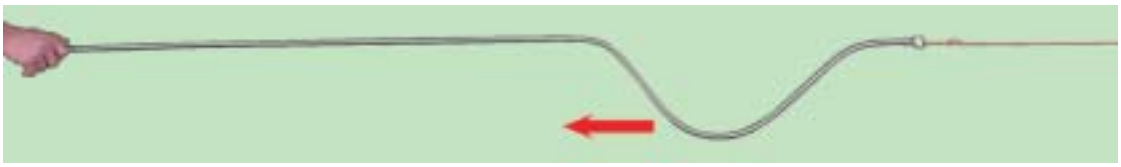


222

Wave reflection
from a fixed end

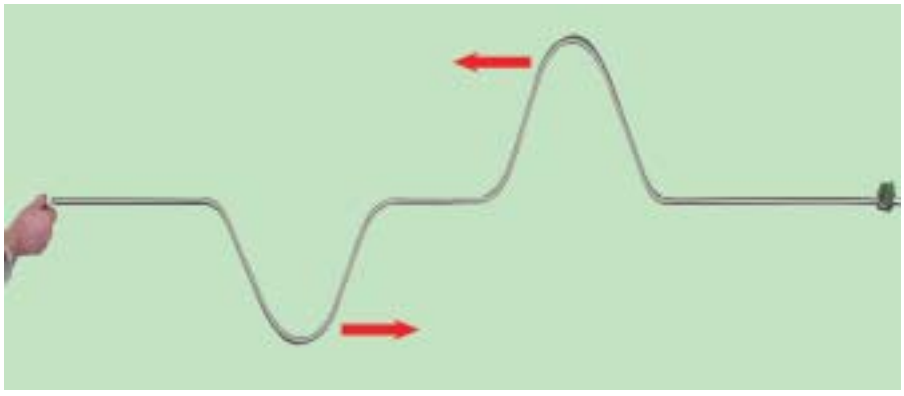






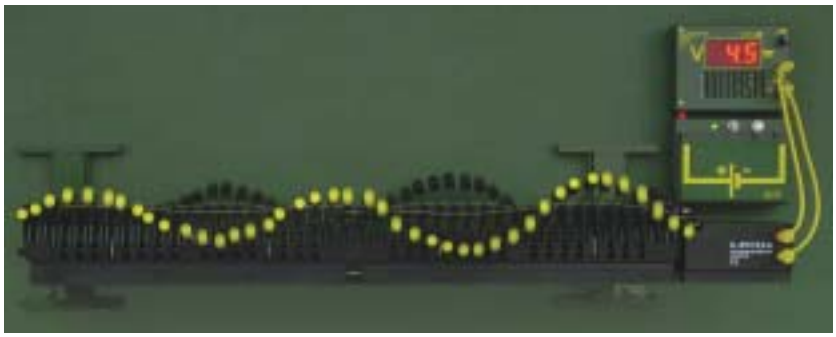
223

Wave reflection from a loose end

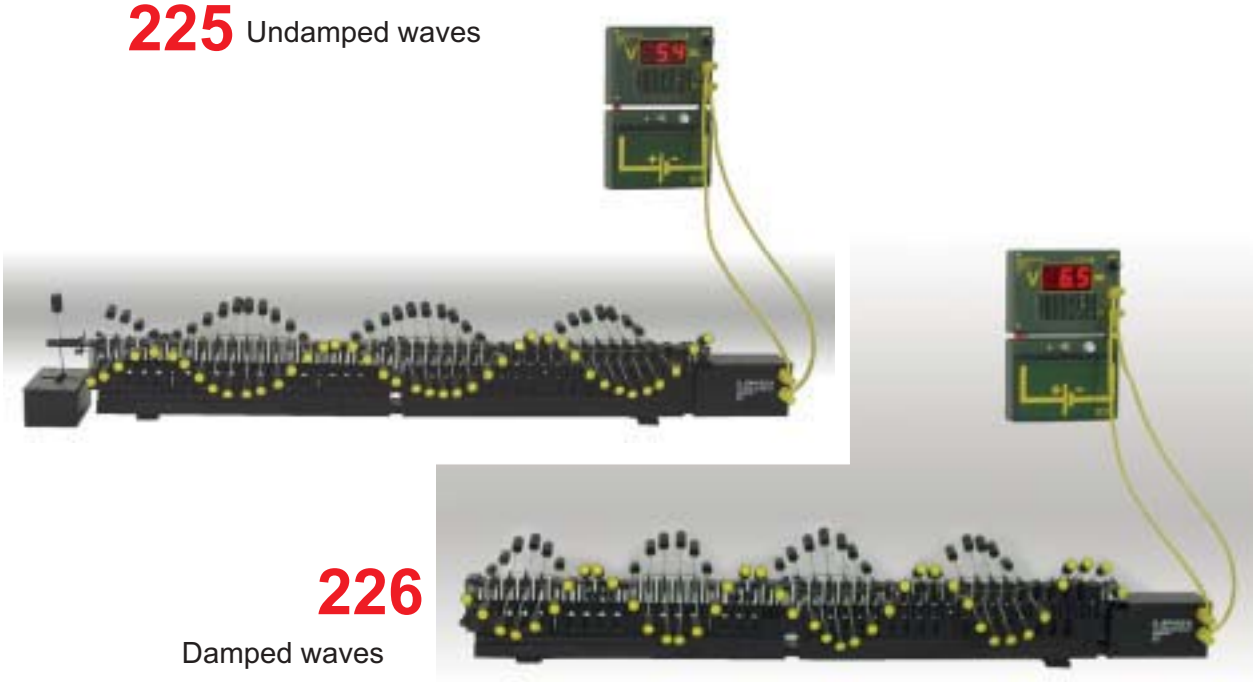


224

Wave interference

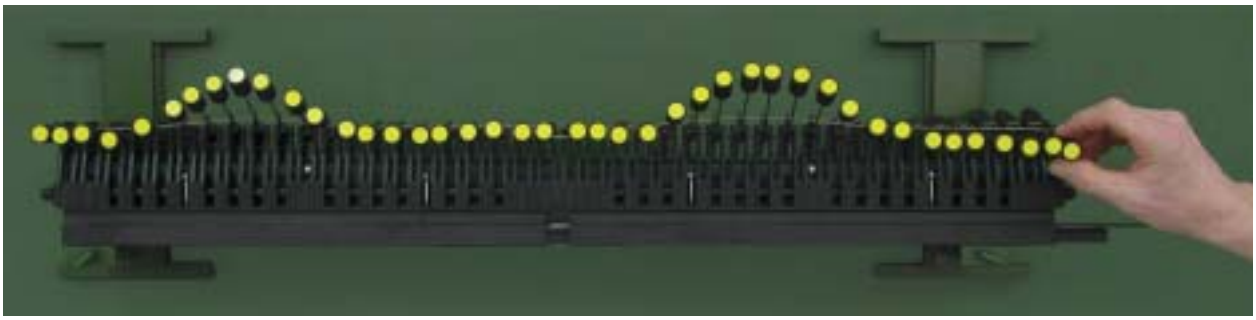


225 Undamped waves

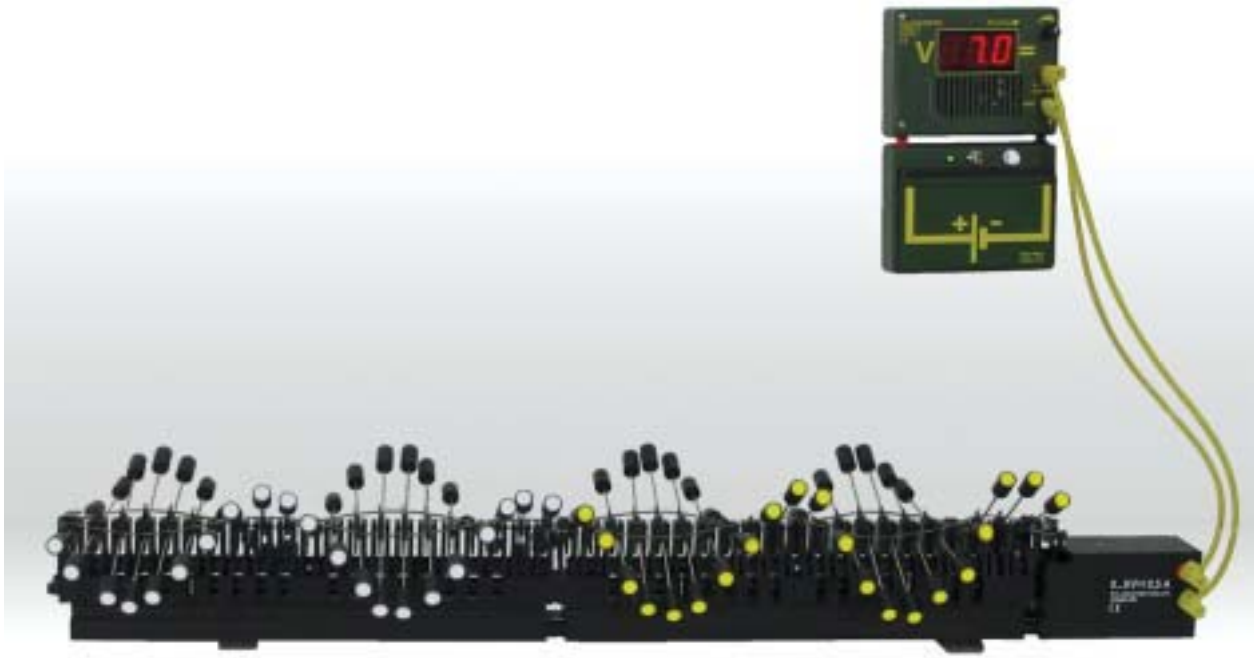


226
Damped waves

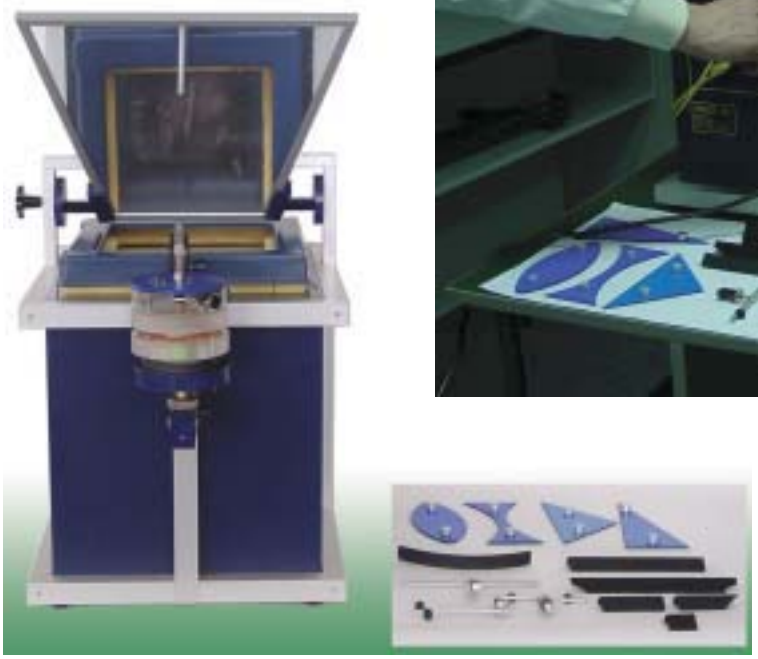
227 Wave reflection from a fixed end:
destructive interference



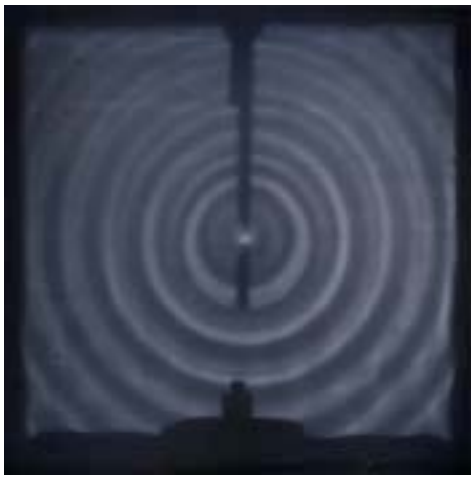
228 Wave reflection from a loose end:
constructive interference



229 Changing wave length



Ripple tank with accessories DW400-1W

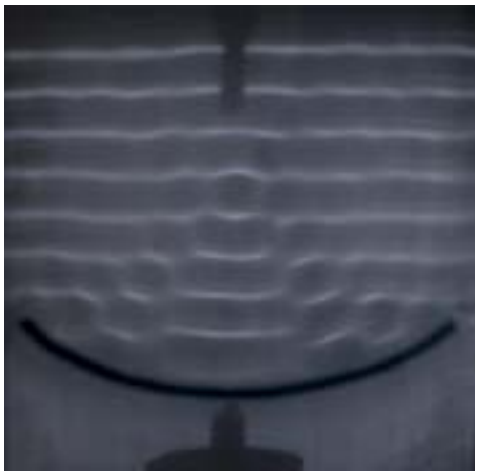


230 Concentric waves

231 Smooth waves

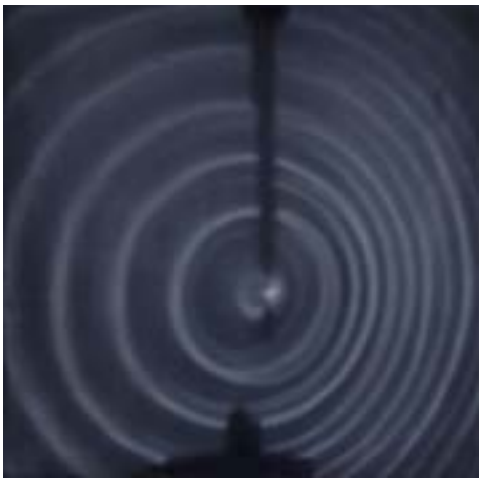
232 Reflection from a smooth obstacle

233 Refraction in a prism



234 Reflection in a concave mirror

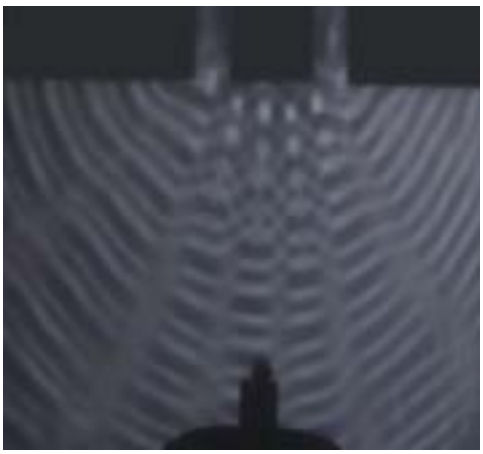
235 Effect of a lens



236 Doppler effect

237 Interference of two concentric waves

238 Diffraction at a trough



239 Diffraction at a double trough

240 Chaotic penduluml

MECHANICS

DM722-1N Box-Newtonmeter
0 – 20 N, 0 – 2 kg

DM723-1N Box-Millinewtonmeter
0 – 20 mN, 0 – 20 g

DE722-1D Box-Manometer absolute

DE722-2D Box-Manometer differential

MECHANICS

P3120-1D Box-Time measurement device

DE722-1W Box-Stopwatch

P3120-2F Box-Battery
for P3120-3L/3R

DE722-2W Remote switch
for box-stopwatch

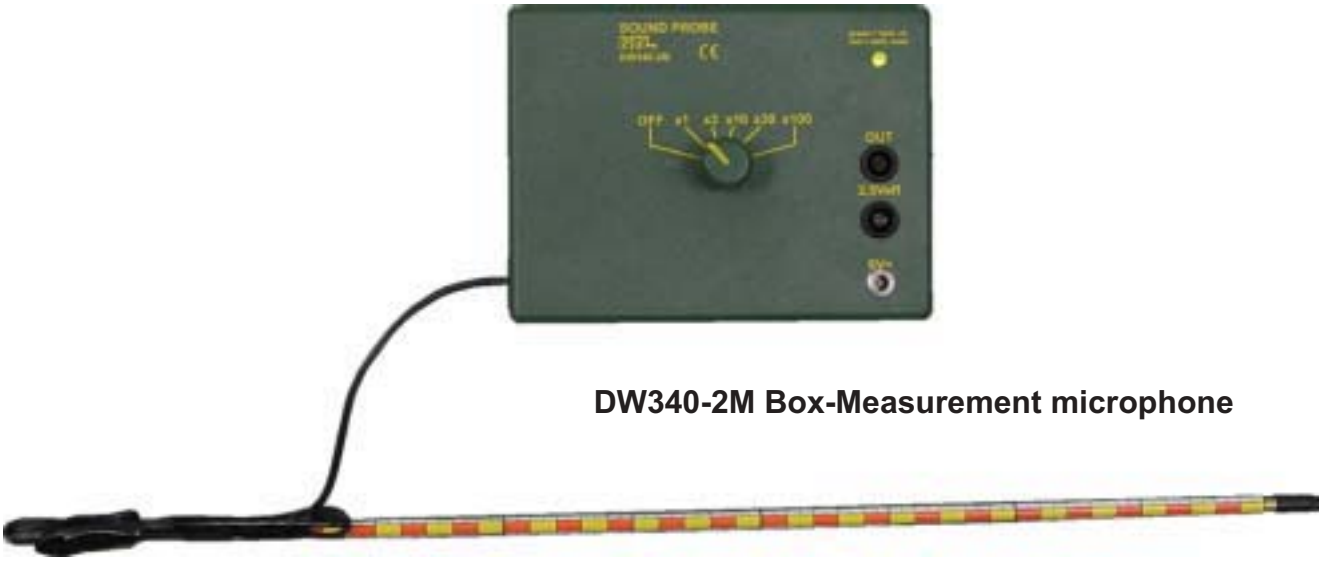
DT816-2A Box-Anemometer

DM341-1T Box-Time measurement device
for falling-sphere device

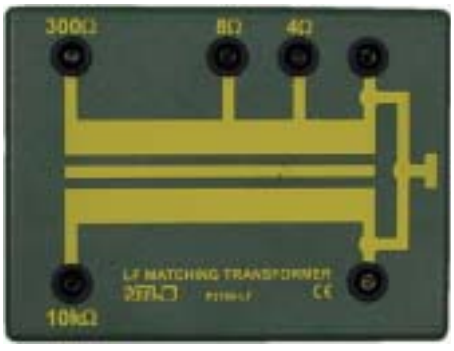
ACOUSTICS

DE722-1F Box-Frequency counter

DW275-1M Box-Sound level measuring device



DW340-2M Box-Measurement microphone



P3180-LF Box-LF-transformer

ELECTROSTATICS

DE722-1H Box-Electrostatic voltmeter 0 – 18 kV

P3127-1V Box-High-voltage device 0 – 18 kV

ATOMIC PHYSICS

DE722-1G Box-Geiger-Mueller counter

OPTICS

DL722-2L Box-Light meter

DL100-3L Box-Laser 635 nm

CHEMISTRY

P3120-1P Box-pH-meter

DE722-1L Box - Conductimeter

ELECTRICITY Power Supplies and Measuring Instruments

cf. catalogue of experiments and instruments PHYSICS 0106, pp. 103 ff