LESSON PLANS

Targets, objectives & scenes for lessons

INDEX - ALGODOO LESSONS

ABOUT ALGODOO

ALGODOO is a unique 2D-simulation environment for creating interactive scenes in a playful, cartoony manner. Algodoo is designed to encourage students and children's creativity, ability and motivation to construct knowledge, making use of the physics that explains our real world. The synergy of science and art makes Algodoo as educational as it is entertaining.

ALGODOO´S MAIN FEATURES

- FUNCTIONALITY - Create and edit using simple drawing tools. Interact by click and drag, tilt and shake. Play and pause scenes, change material and appearance of objects. Use color traces, graphs, forces, etc. for enhanced visualization. Change and make your own user skins or create unique palettes for objects and backgrounds.

- PHYSICAL ELEMENTS - Build and explore with rigid bodies, fluids, chains, gears, gravity, friction, restitution, springs, hinges, motors, light rays, optics, lenses.

- TUTORIALS - Algodoo has several built in tutorials to get started. Have a "Crash course" to learn basic features of the software or try the "Sketch tool tutorial" for drawing and interacting with one multi sketch tool.

- METHODS - Algodoo is based on the latest technologies, from Algoryx Simulations, for interactive multiphysics simulation, including variational mechanical integrators and high performance numerical methods.

EDUCATIONAL USE

As educational software, Algodoo applies a constructionist learning paradigm, that is, learning by actually making simulations and not just running pre-made systems. The open-endedness of Algodoo is very important as a creative and motivational aspect for users. This use model is accompanied with a lively community web site, tutorials, a number of pre-made scenes and examples, sample lessons, and on-line user created scene repository.

Several research projects are initiated that study learning and motivational aspects of Algodoo. Algoryx's ambition is to continue developing Algodoo based on input from user feedback and from academic science education research, and also further develop more educational material, use and evaluation models based on this.

INTRODUCTION

This document is a guide in how to use Algodoo in lessons. Algodoo "Lesson plans" targets education at several different levels. For convenience, we refer to different ages for defining these levels, but this could also be mapped to most educational classification systems today. More lessons can be found at www.algodoo.com.

AGES 5 – 7

The main objectives of this stage include encouraging children to think creatively about science. Here Algodoo lesson plans are used to give an introduction to the most basic concepts such as motion and gravity. This is mainly done through creative and playful use of Algodoo where teacher and kids can use Algodoo as a digital toy in the classroom.

AGES 7 - 11

In this lesson stage the children get more and more familiar with models to represent things they cannot directly experiment with in real life. They can make links to different phenomena visualized in Algodoo with their personal experiences. Slightly more advanced lesson concepts are introduced here, such as mass, density and buoyancy, forces and acceleration, velocity, friction and restitution of different materials.

AGES 11 - 14

When the children enter this level, visualization of forces and velocities, as well as the plotting functionality will have increasing importance. Conservation laws can be studied and experimented with in lessons. Linear and angular motion as well as the corresponding forces and torques can be introduced and explored.

AGES 14 -

In this lesson stage emphasis is on understanding the relation between different concepts and phenomena. Force and velocity visualizations are important tools in exploring and evaluating Algodoo scenes. Another important concept is energy which is visualized by the plotting functionality. The force of gravity is further explored and phenomena like center of gravity, moment of force and equilibrium can be visualized by creating scenes in Algodoo.

TOOLS GUIDE

Sketch tool - Is a unique multi tool for doing most of Algodoo´s editing based on simple gestures. Draw different shapes, boxes, circles, polygons, hinges, springs, chains, etc. with it. Interact with objects by dragging, rotating and moving them. See the "Sketch tool tutorial" in Algodoo for more information.

TOOLS MENU

Move - Move objects or water.

Drag tool - Drag and apply forces to objects during simulation.

Rotate - Rotate objects and water.

Scale - Change size and make things smaller or larger. For proportional scaling hold SHIFT.

Cut - Cut or divide objects by drawing a line through them. Hold SHIFT for a straight cut.

Polygon - Draw arbitrarily shapes. Hold SHIFT to draw straight lines.

Brush - Works like a painter brush. Draw with the left mouse button, erase with the right.

Box tool - Makes a box. Hold SHIFT for a square.

Circle tool - Create circles.

Gear - Create gears. Double click the gear icon for more options.

Plane - Creates infinite planes. Useful for making a ground plane, a wall or a sealing.

Chain - Make a chain or make a link between objects or to the background.

Spring - Connects any two objects with a spring.

Fixate - Weld two objects together or one to the background.

Hinge - Connects two objects with a hinge. In Settings menu you can turn a hinge in to a motor.

Tracer - Attach a tracer to an object and it will draw its trajectory.

Laser pen - Creates a laser beam. Change color of the beam in Settings menu - Appearance.

Texture tool- Scale textures to fit on an object.

SIMULATION CONTROL

Start simulation. Activates gravity and air buoyancy. Objects start to move.

Pause - Pause simulation. Create, change and analyse objects when the scene is paused.

Undo - Undo your changes. Push several times for undoing more steps.

Redo - Redo your changes.

Gravity - Turn on and off gravity.

Air friction - Turns on and off air buoyancy and air friction.

1. CREATE SCENES WITH ALGODOO

Target	Teachers, students
Description	Getting familiar with the Algodoo environment, the tools and menus by creating a scene and interacting with it.
Learning objectives	Getting familiar with the Algodoo environment
Time frame	30 – 60 min
In class	Let the students explore the possibilities of Algodoo. Browse through the menus to see what is in there. By choosing **File:Load scene** you can load different scenes. The simulation can be started and stopped at any time. The accelerometer can be turned off and on. While the simulation is running you can pull objects by using the hand tool. You can add new objects any time. Your simulation is saved by choosing **File:Save scene**.

1. Create planes, one on each wall/floor/ceiling.

2. Use at least two boxes.

3. Use at least two circles.

4. Use at least one spring.

5. Make at least one free form.

6. If possible tilt the device to make use of the accelerometer.

7. Use the CSG-tool to create an object.

8. Use the knife to cut objects into pieces

9. Change properties (color, material) of one of the objects.

10. Take a snapshot with the camera (if your computer have one) and add the object to your scene.

11. Add a hinge and assign a motor to it.

12. Create something that moves by using hinges, motor, or by constructing own driving arrangements.

13. Add a pen to an object in order to follow its trajectory.

14. Turn on force and velocity visualization.

15. Interact with the objects by pulling them.

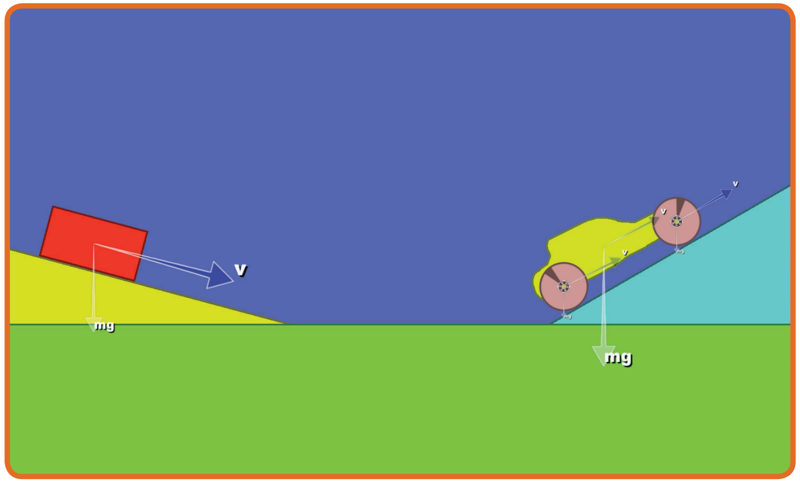
16. Add new objects.

17. Turn one of the objects into water.

18. Turn off and on gravity.

19. Turn off and on air drag.

20. Save your scene.



2. MODEL THE PLAYGROUND (AGES 5-11)

Target	Teacher ages 5-11 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	The students are well familiar to the playground and there are many phenomena in that environment that can be examined making use of basic concepts in science. This lesson allows the students to explore the concepts of motion, push and pull, shapes and mechanisms and relate these to well-known everyday phenomena. Furthermore, this lesson serves as an introduction to Algodoo and the scientific idea of modelling, i.e., the idea of representing the real world with a simplified model that can be examined to gain understanding and to make testable predictions.
Learning objectives	Knowing about the concepts of motion, push and pull, weight and balance. The ideas of modeling, predicting and testing. Create computer models representing real or imaginary objects.
Time frame	30 – 60 min
Keywords	Motion, push, pull, weight, balance, mechanism, model
In class	Let the students make scenes in Algodoo of a playground, a favorite part of it or an outdoor toy. Let the students become familiar with the basic drawing tools to create different shapes. Guide the students also to make use of hinge, fixate, spring, chain, gears in their creations. Examine the scenes together with the students. Ask the students to describe what motions can be observed and their relation to push and pull. Ask the students to describe their mechanisms or toy and lead them to use the concepts of weight and balance. Try to use the models to make a clear prediction that can be tested in the playground. Will it work out? Ask the student to describe what differences there are between their model and the real world. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. The lesson can be followed up with a visit to the playground for testing the predictions. Another follow-up or extra exercise can be to invent a new playground using Algodoo. Let the students present their models for the class.

CREATE A SCENE

Create a plane. Draw the playground by creating objects of different shapes. Connect the objects using the tools for hinge, fixate, chain etc. to make them into mechanisms or toy that can be found in the playground.

MAKE A PREDICTION

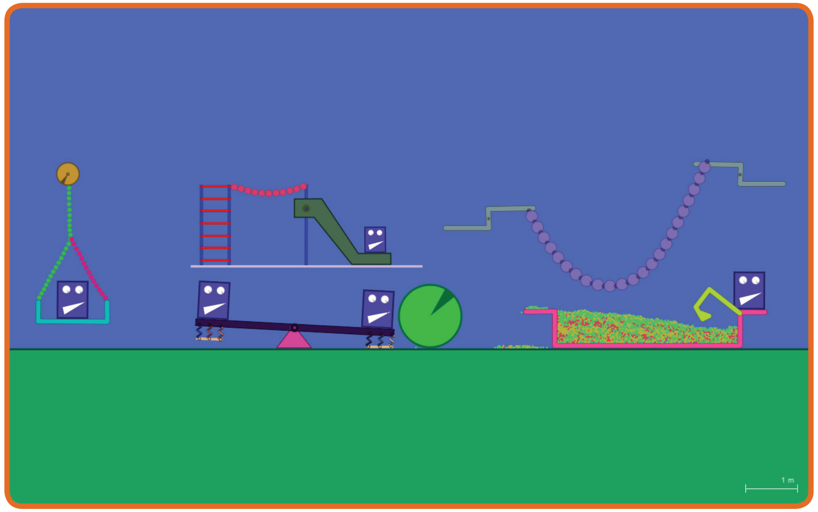
What makes the playground mechanisms work?
Do the objects have to be pushed or pulled?
What is the influence of weight?

RUN/INTERACT

Run the simulation and interact with it.

EVALUATE

Did the playground mechanism work as in the real world? Try to improve the model!

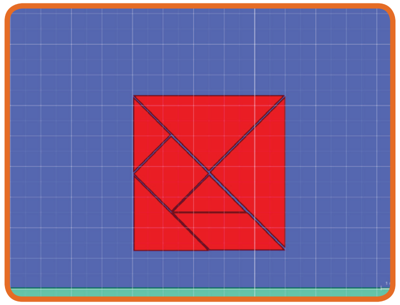


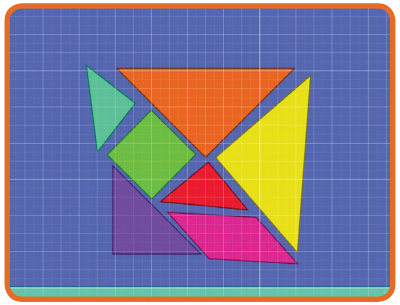
3. TANGRAM (AGES 5-11)

Target	Teacher ages 5-11 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	In this lesson students will create a tangram puzzle and work with different shapes. Build new shapes and investigate how the shapes are related to each other. The areas of the tans are given by Algodoo but can also be calculated as an exercise for older students.
Learning objectives	Use spatial memory skills. Use spatial visualization skills. Learn geometric shapes. Apply flips, slides and turns to geometric shapes.
Time frame	30 – 60 min
Keywords	Shape, square, rectangle, triangle, right triangle, parallelogram, area
In class	Ask if anybody knows what a tangram is. Draw a square on the board and create the pieces, tans, by drawing the five lines with help from the students. Discuss what different shapes that appear. Discuss the concept of area. Discuss how the tans are related to each other. Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation.

CREATE A SCENE

Turn on the grid and create a square with a side of 10 grid squares. Use the knife tool and cut the square in the seven tans. Use an ordinary ruler to make straight lines. Start with the diagonal cut followed by the cut between the middles of the square side.





MAKE A PREDICTION

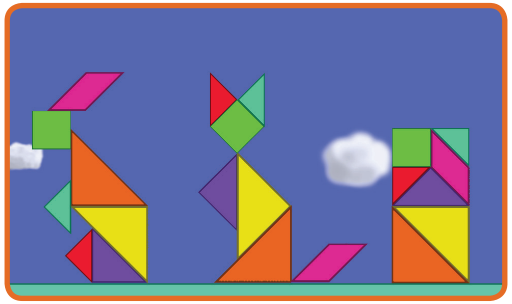
Is it possible to make the different shapes using all the tans? What is the area of each tan? Is it possible to mirror/flip a shape?

RUN/INTERACT

If you run the simulation and the tans fall. Turn off the grid and pause the simulation. Move and rotate the tans in order to build shapes. Build for example a square, a rectangle and create new shapes.

EVALUATE

What are the relations between the areas of the different tans? What happens when you flip the tans? Do they represent the same shape?

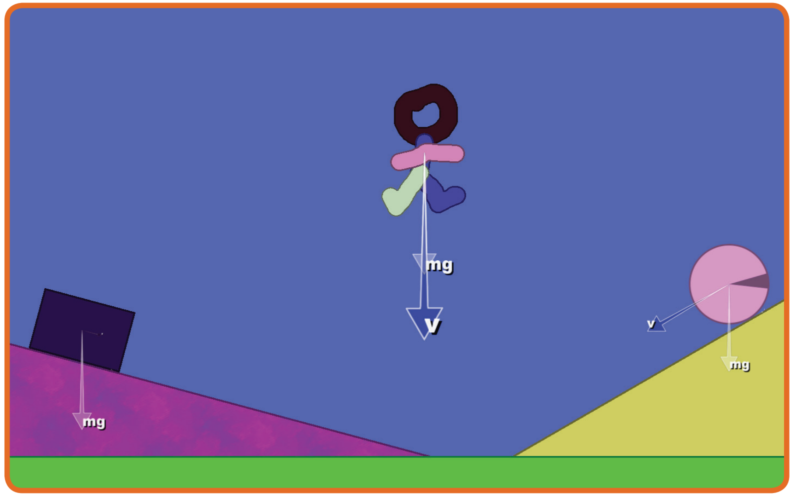


4. MOTION (AGES 5-11)

Target	Teacher ages 5-11 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	Motion is a fundamental concept in science. This lesson explores different causes of motion, such as pull, push, drop (gravity), and also introduces the term force.
Learning objectives	Knowing different ways of setting an object into motion. Knowing a cause of motion (push, pull, drop, slide) in terms of influence of a force. Knowing about the relation between speed, distance and time.
Time frame	30 – 60 min
Keywords	Motion, force, push, pull, gravity
In class	Discuss what causes an object to move. Let the students suggest different ways of setting an object into motion and list them on the whiteboard. For example pushing, pulling, throwing, dropping, sliding, adding a motor. Discuss that the cause of motion is called force. Discuss how the size of the force influences the motion. Discuss relation between speed, distance and time. Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation.

CREATE A SCENE

Create a horizontal plane and one plane as a slope. Make objets that can roll, slide, driven by a motor, fall.



MAKE A PREDICTION

How can the object be set into motion?
What makes the object stop?

RUN/INTERACT

Explore different ways of moving the object. Rotate the planes (if you have a computer with accelerometer, tilt the PC) and move objects, watch the object slide down the plane or fall through the air. Turn off and on gravity and explore its influence on the motion. Grab the object by using the hand tool. Push and pull and make the objects move in different ways.

EVALUATE

What are the different causes of motion in the cases?
What is needed in order to set an object into motion?

5. WHY ARE WHEELS CIRCULAR IN SHAPE? (AGES 5-11)

Target	Teacher ages 5-11 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	This lesson allows the student to examine the motion of circular, triangular, rectangular and irregular objects on a plane. What type of motions can be observed? Can boxes roll? Build a simple transportation vehicle. Experiment with with different shapes on the wheels. Why are wheels circular in shape?
Learning objectives	Knowing about rolling motion Understanding of the wheel and simple transportation vehicles Evaluate different designs
Time frame	30 – 60 min
Keywords	Rolling motion, wheel, axel, vehicle
In class	Start by discussing the problem of moving heavy objects over distances. - What type of machines are there? - When are wheeled machines used for this? - What are the drawbacks with using other machines - e.g. cranes have limitied range, flying machines and robots are expensive? - Are there wheeled vehicles with no motor? Use Algodoo for studying the motion of circular, rectangular and irregular objects on a plane. - What type of motions are observed? - What is special with rolling? - Can a box roll? Experiment with dragging a heavy box over objects of different shapes. Let the student construct simple vehicles with wheels of different shapes. Why are wheels circular in shape? Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate.**

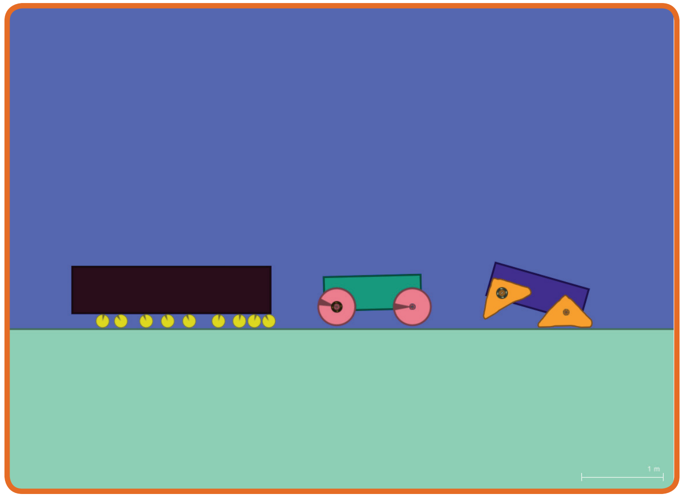
CREATE A SCENE
Create a plane. Create circular, rectangular and irregular objects and study their motion.
What type of motions are observed?
What is special with rolling?
Can a box roll?

Experiment with dragging a heavy box over objects of different shapes.
What is the behaviour?

MAKE A PREDICTION
Construct a vehicle by connecting the center of the wheels to the vehicle body using the hinge tool. This is similar to the axel in the car.
How will a vehicle with irregular shaped wheels behave?
What are the advantages of having circular shaped wheels?

RUN/INTERACT
Run the simulation and interact with it.

EVALUATE
What behaviour is observed with the different wheel shapes?
How long do they roll?
Adding a motor to the hinge and visualizing velocity arrows may help the analysis.



6. SWING (AGES 7-11)

Target	Teacher ages 7-11 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	Swing motion is a good system for examining the concepts of force and motion. Several forces interplay. In reality the forces can be experienced, e.g., as the tickling sensation of acceleration under gravity and the pressure from the swing on the body. Velocity can be experienced through the air drag. This lesson allows the students to visualize the forces that are present in a swing and understand their relation to the swinging motion.
Learning objectives	Understanding of gravity as a force present at all times. Knowing about force as a cause of change in motion. Knowing that several forces may interplay. Understand the forces interplaying in swinging motion.
Time frame	30 – 60 min
Keywords	Swing motion, gravity, force
In class	Discuss different swing designs. Discuss what makes a swing start to move and what that motion looks like. When is the velocity at maximum speed? What is the velocity at the turn points? What makes the swing turn? Make a simple drawing of a swing carrying a student (modelled as a box, say) sitting on a seat. Let the students create the scene in Algodoo. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Study the forces by visualizing them as arrows. Study also the velocity visualized as arrows. Observe that gravity is present as a constant force but that the force between the seat and the student varies. Observe also that there is a force from the student to the seat – this is a contact force we experience as pressure from the seat. Connect to the real experience of swinging. Observe how the velocity changes with time. Ask the students what would happen if there was no gravity. Test this by setting gravity to zero.

CREATE A SCENE

Create a plane. Create a swing using rigid elements and the hinge tool. You can also use the chain tool for more realism.

MAKE A PREDICTION

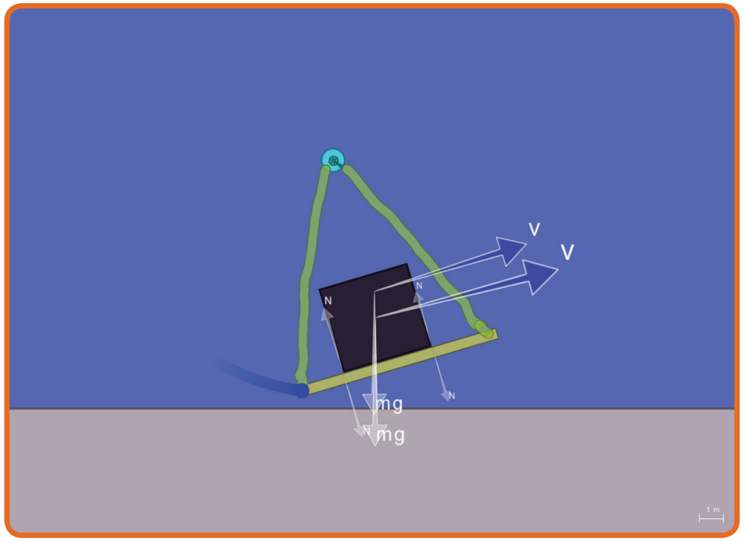
Study the swing motion.
When is the velocity at maximum value?
Is the velocity ever zero?
When is the contact force from swing to body at it its maximum. Why?
Is the contact force ever zero?
What happens if there is no gravity?

RUN/INTERACT

Run the simulation and interact with it.

EVALUATE

Study how the forces and velocities vary with time. Add a tracer to the swing to enhance the shape of the motion.

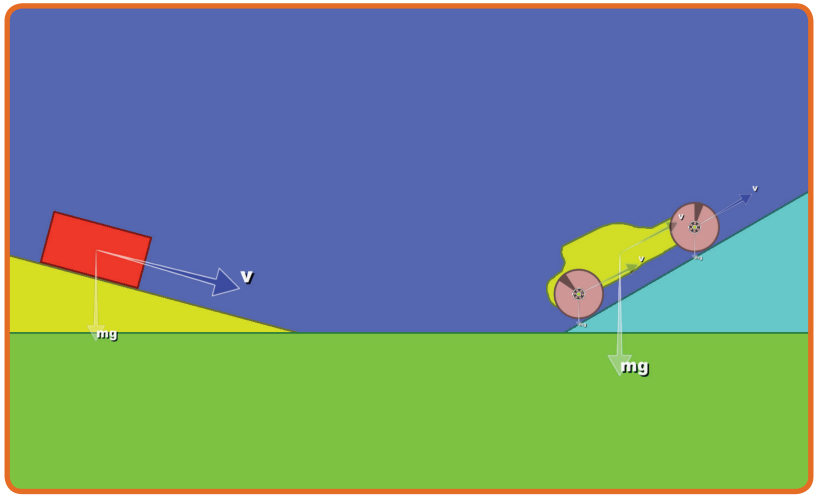


7. ROLLING DOWN A RAMP (AGES 7-11)

Target	Teacher ages 7-11 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	Letting objects roll or slide down a ramp opens possibilities to explore causes and effects of motion. The students can make suggestions of what to investigate and how to test Explore the aspects of how far up on the ramp the object starts, the material of the ramp, the amount of slope and how that affects the motion.
Learning objectives	Asking questions to the situation. Plan an experiment. Predict what might happen. Evaluate the result. Explore the cause of the motion.
Time frame	30 – 60 min
Keywords	Motion, force, push, pull, speed, distance
In class	Discuss what happens when an object rolls or slides down a ramp. Discuss what questions that are interesting to ask in order to explain the motion. Discuss how the height, the slope and the material influence the motion. What happens at the end of the ramp when the plane is flat? When the plane is going upwards again? What makes the object stop? What makes it continue its motion? How should the ramp look like in order to get an object to move as far as possible. Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation.

CREATE A SCENE

Use a plane as a ramp. Create an object (a box, a car with wheels, take a picture of an object). Add one or two planes to create a track with downhill, flat ground and uphill.



MAKE A PREDICTION

How can the object be set into motion?
What makes the object stop?

RUN/INTERACT

Let the object slide or roll down the ramp. Rotate the plane (if you have a computer with accelerometer, tilt the PC) to model different slopes.
Let the object slide or roll down to a flat surface and see how far it goes.
Let the object roll or slide down to an uphill and see how high up it goes.
Change the material of the ramp to give it more or less friction and explore the motion.

EVALUATE

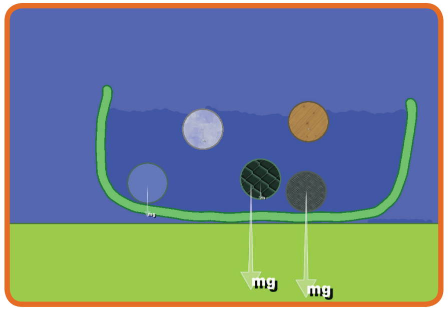
When does the object roll really far?
When does it roll high?
How does the material influence the motion?

8. FLOAT AND SINK (AGES 7-11)

Target	Teacher ages 7-11 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	The students will create objects of different shapes and materials and investigate whether they sink and float. Investigate properties of different shapes of the same material. How can steel float? Besides assigning material properties to objects, the students can also be introduced to density and investigate how numerical values of density relates to density of water. What is the density of water, when does an object neither float or sink?
Learning objectives	Predict and observe the buoyancy of objects of different materials. Investigate how the density of an object affects its buoyancy.
Time frame	30 – 60 min
Keywords	Float, sink, density, buoyancy
In class	Discuss what objects sink and what objects float. Discuss what make objects float. Why does a boat made of steel float? How does an iceberg float? Put up suggestions on the board. Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation.

CREATE A SCENE

Create a container, about 2 m wide by using for example the brush tool. Drawing a large body inside the container and select Liquify under Geometry actions. Run the simulation to fill the container. Create an object and clone it to make a number of objects of equal size. Assign different material to the objects.



MAKE A PREDICTION

Which objects will float and which will sink?

RUN/INTERACT

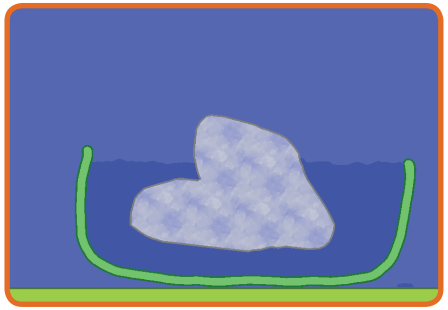
Run the simulation and watch objects float and sink.

EVALUATE

What properties are different between the objects? Why do some float and why do some sink? What happens with the water when the objects are put in?

REVISE SCENE

Create an iceberg. Remove items from the container if it gets too crowded.



MAKE A PREDICTION

How do you expect the iceberg to float?
What happens when the iceberg melts or pieces fall off?
What happens if you turn the iceberg into water?

RUN/INTERACT

Run the simulation. Use the knife and cut pieces of the iceberg to change its shape. You may have to remove the pieces.

EVALUATE

How does the iceberg float?
What happens when its shape is changed?
How does the water level change when the iceberg melts?

9. MIRRORS (AGES 7-11)

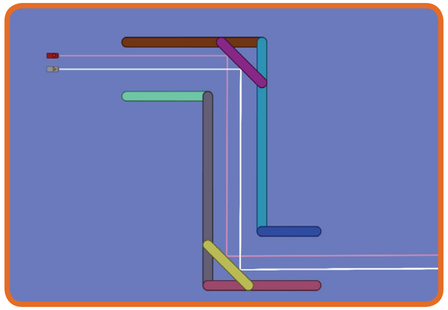
Target	Teacher ages 7-11 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	In this lesson students investigate the reflection of mirrors to direct light. They build devices that send light in different directions, for example a periscope.
Learning objectives	To explore the effects of mirrors on the passage of light. Understand how a periscope works. To explore a simple optical labyrinth.
Time frame	30 – 60 min
Keywords	Reflection, mirror
In class	Discuss what tools that helps us see better. Put up the suggestions on the board, for example glasses, binoculars, telescopes. Discuss what these tools do. Discuss if there are times when these tools do not help. Let the students give suggestions on how it is possible to see and shine light around corners. Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation.

CREATE A SCENE

Create a periscope. Mirrors are modelled by setting index of refraction to infinity. Use for example two lasers of different colors to represent the object that is observed through the periscope.

MAKE A PREDICTION

What angle should the mirrors have?
Will the picture appear upside down?



RUN/INTERACT

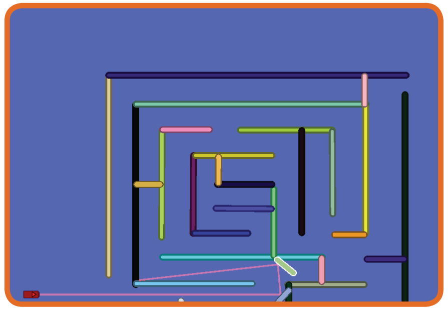
Rotate mirrors to see what happens to the light beams. Rotate lasers to see what happens to the beam.

EVALUATE

How does the angle between the light beam and the mirror affect the reflected light beam?

REVISE SCENE

Create a laser labyrinth with a starting point and an end point using for example the brush tool. Put a laser at the starting point. Set the fading distance of the laser to maximum.



MAKE A PREDICTION

How can the laser beam be guided through the labyrinth?

RUN/INTERACT

Put mirrors in the labyrinth in order to guide the laser beam through the labyrinth. Use for example the brush tool to make the mirrors and set the index of refraction to infinity. Rotate and move mirrors for guiding.

EVALUATE

Based on your solution to the labyrinth, is it possible to use fewer mirrors?

10. RAINBOWS (AGES 7-11)

Target	Teacher ages 7-11 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	The rainbow is a good starting point when discussing properties of light. The students investigate the influence of prisms and other transparent objects when passed by light beams. A rainbow can be modelled by letting white light refract in a transparent circle, representing a raindrop.
Learning objectives	Understand that white light is a mix of all colours (wavelengths). Know the colours of the rainbow.
Time frame	30 – 60 min
Keywords	Visible light, prism, rainbow, spectrum, refraction, speed of light
In class	Start with discussing the rainbow. How and when does a rainbow appear? Where does the light come from? Where do the colours come from? Let the students come up with suggestions. Discuss how white light can split up into rainbow colours. Discuss other phenomena when rainbow colours appear. Demonstrate how a prisms refracts white light. Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation.

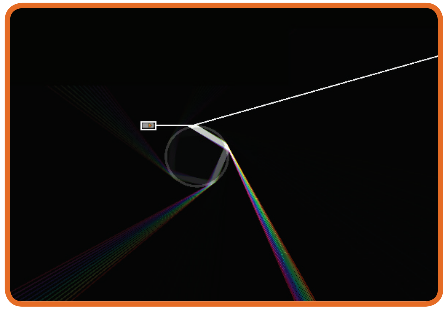
CREATE A SCENE
Create a prism by using the polygon tool and setting material to glass.

MAKE A PREDICTION
What happens when white light hit the prism? Is the light white all the way through the prism? What happens when the color of the laser beam is changed? Do all colors behave the same?

RUN/INTERACT
Let a white light beam shine at the prism. Create white light by decreasing Saturation. Rotate the prism, move the light beam to watch the effects.

EVALUATE
Add more glass objects after the prism and investigate what happens with the scattered light from the prism. How do the different colors behave? Do they refract in the same way?

REVISE SCENE
Model a raindrop by creating a transparent circle with refraction index 1.3.



The rainbow appears because the intensity of the reflected beam depends on the angle between the incident beam and the reflected beam. The most intense beam is at 40°-42°. This is not the case for the light that goes through the raindrop which means that it will be blended and appears white.

MAKE A PREDICTION
What happens with a white light beam when it hits the raindrop?

RUN/INTERACT
Let a white laser represent the sun and let the beam hit the raindrop. Rotate laser or move it up and down to alter the angle of incidence. What happens with the intensity of the refracted light?

EVALUATE
Which refracted beam is actually the rainbow? What happens with the light that goes out on the other side of the rainbow?

11. CENTRE OF GRAVITY (AGES 11-14)

Target	Teacher ages 11-14 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	The centre of gravity of a body is the point in which the mass of the body can be concentrated. Gravity acts as if all the mass of the body is concentrated in that point. This lesson allows the student to explore the concept of gravity and to find the centre of gravity of an irregular body.
Learning objectives	Understand and explain the concept of centre of gravity. Discuss methods of finding centre of gravity of an irregular body. Model a situation for centre of gravity and create an interactive simulation.
Time frame	30 – 60 min
Keywords	Centre of gravity, mass
In class	Discuss the centre of gravity. What does it mean and what effect does this phenomenon have in real life? How can the centre of gravity of a body be found? Discuss possible ways of doing this with the class and put up suggestions on the board. Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation.

CREATE A SCENE
Create an irregular body, using for example the brush and the CGS-tool, or use a camera to take a picture of your friend and use her shape. Clean-cut the picture and suspend the body using a hinge.

MAKE A PREDICTION
Estimate the center of gravity.

RUN/INTERACT
Start the simulation. The body will probably start oscillating so it might be necessary to help stopping it using the hand tool. When still, glue a massless, vertical, straight line from the hinge. Choose another spot for the hinge and glue another massless, vertical line. Repeat a couple of times to get 3-4 lines through centre of gravity.

EVALUATE
Where do the lines intersect?
Compare with the gravity vector.

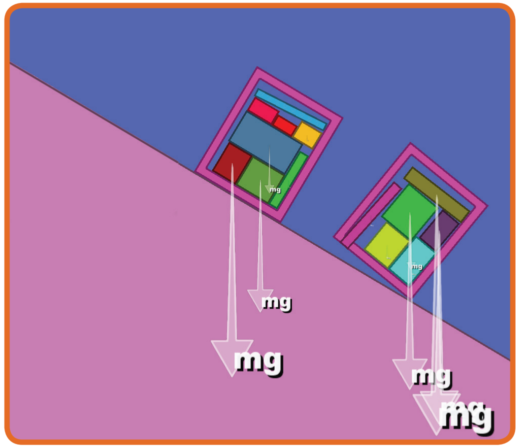
12. TIPPING TRUCK (AGES 11-14)

Target	Teacher ages 11-14 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	Investigate the critical point when a truck is tipping over. The position of centre of gravity is crucial for the balance of a body. This lesson allows the student to explore the concept of gravity and to find consequences rising from the position of centre of gravity. The example explores what causes a loaded truck to tip over, when does a book fall off a table and when does a person loose balance.
Learning objectives	Understand and explain the concept of centre of gravity. Understanding consequences of the position of the centre of gravity of an object. Understand and explain why an objects tips over/looses balance. Model a situation which demonstrates tipping over and create an interactive simulation.
Time frame	30 – 60 min
Keywords	Centre of gravity, mass
In class	Discuss the centre of gravity. What makes an object tip over? What does it mean and what consequences does this phenomenon have in real life? Discuss possible situations of "tipping over" in class and put up suggestions on the board. Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation.

CREATE A SCENE
Create a plane as a slope and make sure friction is high enough to prevent sliding. Create a number of "trucks" by using boxes with different density to model different ways of loading a truck. The truck should be seen from the rear.

MAKE A PREDICTION
Which truck will tip over first when the plane is tilted?

RUN/INTERACT
Start the simulation. Rotate the plane (if you have a computer with accelerometer, tilt the PC) and watch the trucks tip over.



EVALUATE
Why do the trucks tip over?
How should the truck be loaded in order to prevent tipping over?
Where is the centre of gravity?

Note: Observe the position of the gravity vector.

REVISE SCENE
Rearrange the loading in the trucks in order to make them more stable.

MAKE A PREDICTION
How much can the plane be tilted before a truck will tip over? Which truck will tip over first?

RUN/INTERACT
Start the simulation. Rotate the plane (if you have a computer with accelerometer, tilt the PC) and watch the trucks tip over.

EVALUATE
Why do the trucks tip over? How should the truck be loaded in order to prevent tipping over? What consequences may this have in real life situations?

13. THE SEESAW (AGES 11-14)

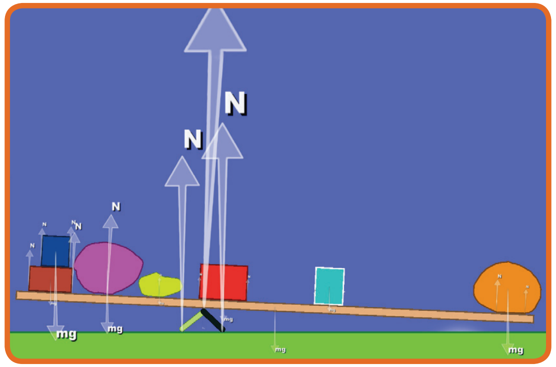
Target	Teacher ages 11-14 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	This lesson allows the student to explore the balance of a seesaw. By adding weights to both sides the seesaw can be kept in balance when using different fulcrums. The relation between mass and distance from the fulcrum can be investigated and give an understanding about lever arms and moment of forces (torques). The example also opens for creating and working with balance scales.
Learning objectives	Understand the relation between mass and distance to maintain balance of a seesaw. Understand the basic principles for a weight scale. Understand what a lever arm is and its relation to moment of force. Model a situation for balance and create an interactive simulation.
Time frame	30 – 60 min
Keywords	Centre of gravity, moment of force (torque), lever arm
In class	Discuss balance of a seesaw. How is it constructed and how does is look when no one is playing with it? What happens when kids of different sizes start playing it? Does it depend where they sit, how tall they are, what mass they have? Discuss different aspects of playing with a seesaw in class and put up suggestions on the board. How can the centre of gravity of a seesaw be found? Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation..

CREATE A SCENE
Create a plane. Create a seesaw with a fulcrum and a long rectangular box. Create objects with different sizes and densities and spread them on the seesaw. Or use the camera and take pictures of your friends and yourself.

MAKE A PREDICTION
When is the seesaw in balance?
How does the seesaw's own mass influence balance?

RUN/INTERACT
Start the simulation. Move the objects on the seesaw to make it balanced. Rotate the seesaw (if you have a computer with accelerometer, tilt the PC) and watch the trucks tip over. and observe what happens.

EVALUATE
What happens when an object is moved towards or from the fulcrum respectively?
What is the relation between mass of the object and distance from the fulcrum?
Relate the mass of the object to the normal force and gravity.



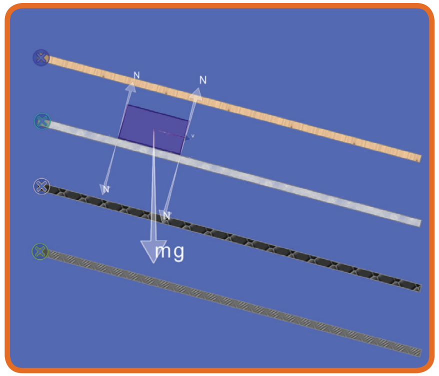
Suggestions for additional scenes modeling center of gravity, moment of force and lever arm:
Balancing book: When does the book fall off the table? Create a book sticking out from a table and find the critical point when the book falls to the floor.
Falling friend: What makes your friend fall with respect to centre of gravity? Take a picture of you friend, clean-cut and stand her on the floor. Tilt/rotate until she falls.
Weight scales: How is a simple scale constructed? Create a scale and use if for weighing different objects.

14. FRICTION OF A SLIDING OBJECT (AGES 11-14)

Target	Teacher ages 11-14 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	Friction is an important concept in understanding motion. This lesson allows the student to explore friction between different types of materials. How does an object behave when it lies on a surface? What happens when the surface is inclined? What influence does the material of the surface have on the motion?
Learning objectives	Distinguish between high friction and low friction. Understand friction as a force. Know about the influence of mass on friction. Know about the influence of contact area on friction.
Time frame	30 – 60 min
Keywords	Friction, force, velocity
In class	Discuss the properties of different surfaces. What does high and low friction means? Discuss everyday situations when high friction is useful (tires on cars and bicycles, shoes, gloves) and when low friction is useful (skating, skiing, playground slides). What happens in a slope with high and low friction respectively? Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation.

CREATE A SCENE
Create several slopes by using the plane tool. Assign different frictions/materials to the slopes. Turn on force and velocity vector visualization. Use a small boxes to investigate friction by letting it slide on the different surfaces.

MAKE A PREDICTION
Are there differences in how the box is picking up speed when sliding down the different surfaces? Why?



RUN/INTERACT
Start the simulation and watch the box slide down the different slopes.

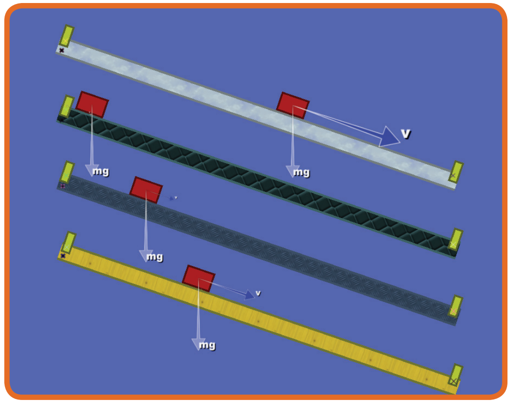
EVALUATE
What happens when the angle of the plane is increased? Decreased? Is it the same for all planes?

DEVELOP SCENE
Create several parallel planes using rectangular boxes of different materials.

Add a stopper on each end to prevent the box from falling off the track. Use identical boxes on each track to watch the simultaneous sliding down the planes with different friction properties.

Investigate the influence on contact area on friction by using boxes of different sizes. Make sure the boxes have the same mass.

Investigate the influence of mass on friction by assigning different mass to the boxes.

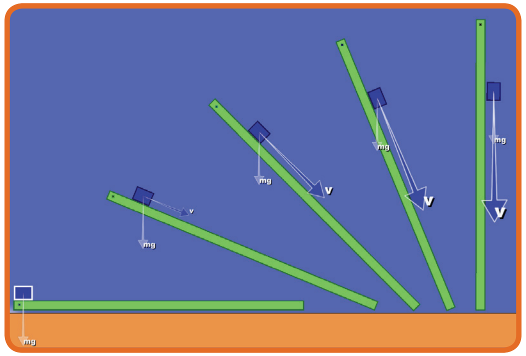


15. GALILEO'S INCLINED PLANES (AGES 11-14)

Target	Teacher ages 11-14 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	Galileo used rolling balls on inclined planes to develop his understanding of acceleration. He did not have proper timing devices to measure the high speeds of free fall and used different angles of inclined planes to model different accelerations. The greater the slope of the incline, the greater the acceleration of the ball. Galileo found a ball rolling down a certain incline picked up same amount of speed for each second. That gain is acceleration.
Learning objectives	Model the acceleration of a falling object using Galileo's inclined planes. Understand the influence of gravity on an object.
Time frame	30 – 60 min
Keywords	Gravity, free fall, acceleration, velocity, force
In class	Discuss how something on a plane can be set into motion. Discuss the experiment that Galileo performed in order to understand the motion of free fall. Why did he do this experiment? Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation.

CREATE A SCENE

Create five rectangular boxes as planes and rotate them to the different angles between 0° and 90°. Make the planes frictionless. Use identical boxes to slide down the planes. A rectangular box, fixed to the background, can be used as a starting device. Remove the shelf at the start to make the boxes start simultaneously.



MAKE A PREDICTION

Which box reaches the end of its plane first?

RUN/INTERACT

Start the simulation and watch the boxes slide down the planes.

EVALUATE

Which plane is faster?
Which ball is picking up the most speed for each second?
Is it possible to check how much speed the balls are picking up?
Run the simulation again and check for velocities. Observe which forces that are involved in the motion. What is the acceleration of the vertical plane? Is there a pattern in how speed is picked up for each plane?

RUN/INTERACT

Run the simulation as an experiment. Make sure that velocity representation and values are turned on. Use a timer and pause the simulation every second. Write down the velocity for each box in a table. Plot velocity as a function of time and study the graphs.

EVALUATE

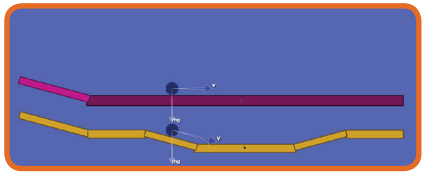
What does the slope of the graph mean?

16. TWO TRACK PROBLEM (AGES 11-14)

Target	Teacher ages 11-14 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	This problem explores the behaviour of two objects rolling on different tracks. How does the shape of the track influence the motion of the balls? The slope causes a gain in speed which will give a higher average speed through the track. The example illustrates how a change in direction means acceleration. It is also possible to discuss how speed and acceleration can be broken up into components parallel and vertical to the ground.
Learning objectives	Understanding how speed can be gained by a slope Acceleration means change in direction or speed.
Time frame	30 – 60 min
Keywords	Acceleration, velocity, gravity, force
In class	Draw the problem on the whiteboard and ask the students which one of the balls reaches the end of the track first. Discuss different aspects of what might influence the motion. Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation.

CREATE A SCENE

Make the two tracks using rectangular boxes. Try to make smooth transitions in order to prevent bouncing. Assign steel to the balls and set the restitution to zero in order to prevent bouncing of the balls.

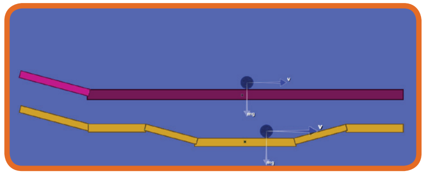


MAKE A PREDICTION

Which boll reaches the end of its track first?

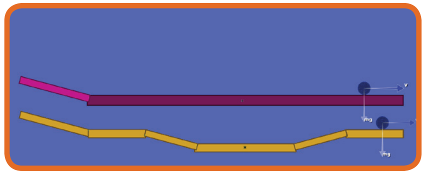
RUN/INTERACT

Collect the bets and start the simulation and watch the ball roll on the two tracks.
Note: Run the simulation without velocity representation first.



EVALUATE

How can we explain that the ball that roll the longest way reaches the finish first?
Discuss changes in velocity. In which places do we have acceleration and how does that affect the motion?



RUN/INTERACT

Run the simulation again and use velocity vector representation to discuss how the box is gaining speed in the slope.

EVALUATE

Which type of track is fastest? Is a straight track always slower than an up-and-down-track?
Make different tracks to check different hypothesis.
Measure the speed of the ball at different places on both tracks and calculate the average speeds.

17. FREE FALL (AGES 11-14)

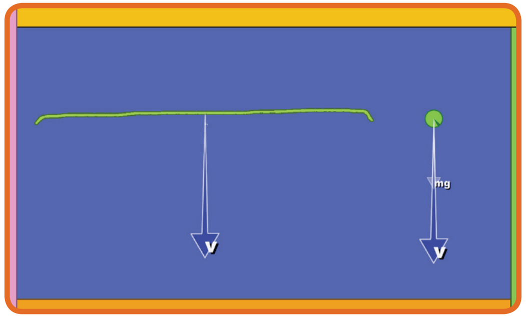
Target	Teacher ages 11-14 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	What variables influence free fall? This lesson treats motion when there are no forces in contact with the object.
Learning objectives	Free fall – falling under the influence of gravitational acceleration only. Air drag – the influence of air drag of a falling object
Time frame	30 – 60 min
Keywords	Free fall, gravity, air drag, force
In class	Drop an object. Discuss what aspects that might influence the motion (mass, shape, falling height). Discuss everyday experiences such as falling leaves, feathers, rocks, parachutists. Collect suggestion from the students and list them on the whiteboard. Discuss possible causes of the falling motion, gravity, air drag. Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation.

FREE FALL - CREATE A SCENE

Create one plane to work as ground and one as a shelf from which objects can fall. Create a number of objects with different shapes and masses for comparison. Make a small light ball, a large heavy ball, assign different materials to the same shape. Make a large featherlight object likely to fall slowly. Let all the objects start from the shelf plane. Make sure that Air drag is turned off.

MAKE A PREDICTION

Which object should come down first?



RUN/INTERACT

Remove the shelf plane, press Play, and watch the objects fall.

EVALUATE

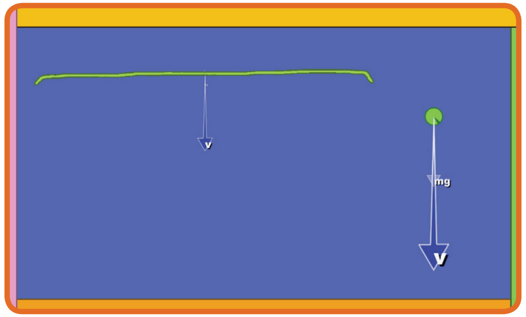
Which object fell to the ground first?
Why? Compare velocities of the falling objects.

FALL WITH AIR DRAG - REVISE THE SCENE

Turn on Air drag. Use the same objects as with the previous scene.

EVALUATE

What does the slope of the graph mean?



MAKE A PREDICTION

Which object will now come down first?

RUN/INTERACT

Remove the shelf plane, press Play, and watch the objects fall.

EVALUATE

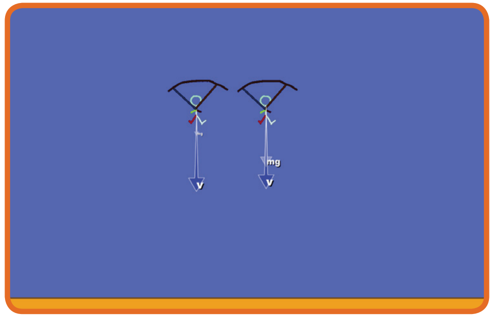
Are there differences in how the objects fall? Compare velocities of the falling objects.

18. PARACHUTING (AGES 11-14)

Target	Teacher ages 11-14 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	This lesson discusses what makes parachutists fall at different speeds, with and without parachute. By manipulating the body to different shapes the parachutist can control his falling velocity. Air drag due to the body only is a lot smaller than when after the parachute is open.
Learning objectives	Free fall – falling under the influence of gravitational acceleration only. Air drag – the influence of air drag of a falling object
Time frame	30 – 60 min
Keywords	Free fall, gravity, air drag, force, terminal velocity
In class	Draw the problem on the whiteboard and ask the students which one of the balls reaches the end of the track first. Discuss different aspects of what might influence the motion. Collect aspects from the students and list them on the whiteboard (gravity, mass, size, shape, air drag, falling height, etc) Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation.

CREATE A SCENE
Draw two parachutists or use the camera to take pictures of your friends. Make one of them twice as heavy as the other. Create one plane as ground and one as a shelf from which the parachutists jump.

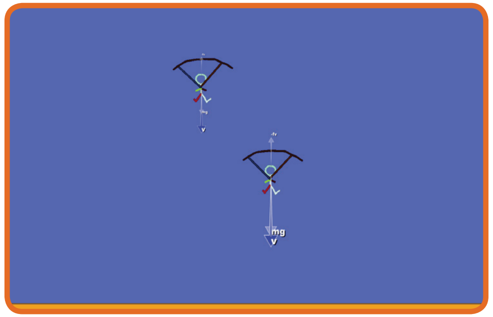
MAKE A PREDICTION
Which parachutist will hit the ground first if there is no air drag?



RUN/INTERACT
Remove the shelf plane, press Play, and watch the parachutists falling.

EVALUATE
Compare the velocities of the two parachutists. How do the shape and mass affect the motion?

REVISE SCENE
Turn on air drag.



RUN/INTERACT
Remove the shelf plane, press Play, and watch the parachutists falling.

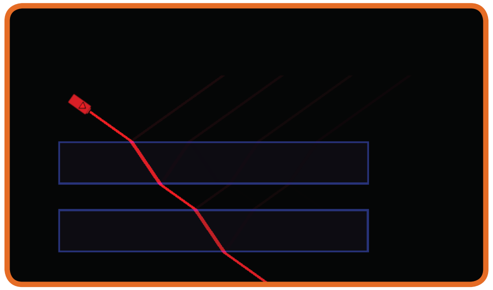
MAKE A PREDICTION
With air drag, which parachutist will now hit the ground first?

EVALUATE
Compare the velocities. How does air drag affect the motion? What is the influence of mass on the motion?

19. REFLECTION AND REFRACTION (AGES 11-14)

Target	Teacher ages 11-14 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	In this lesson students investigate reflection and refraction of light. By altering the angle of incidence the refraction and reflection of a glass object is investigated, including total reflection. Index of refraction can easily be changed and its effect immediately investigated. An optical fibre can easily be created and its influence on light of different colors can be investigated.
Learning objectives	Have a basic understanding of reflection and refraction. Understand that different indices of refraction influences light differently. Have an understanding of how to make a parallel displacement of a light beam. Have an understanding of when total reflection occurs. Have an understanding of how light can travel in an optical fiber.
Time frame	30 – 60 min
Keywords	Refraction, reflection, transparent, opaque, total reflection, angle of incidence, optical fibre
In class	Discuss how different materials affect a beam of light. Discuss how a beam of light can be reflected, refracted and absorbed. What is total reflection? Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation.

CREATE A SCENE
Create glass blocks by using the rectangle tool.

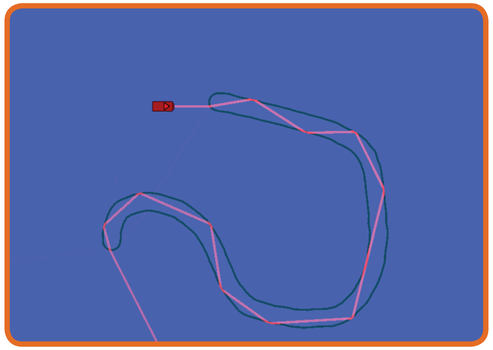


MAKE A PREDICTION
How will the glass influence the laser beam? What happens when light from air hits the glass? What happens when light from glass hits air?

RUN/INTERACT
Point a laser beam towards the glass blocks. Rotate the laser to change the angle of incidence. Change the index of refraction.

EVALUATE
What does a high index of refraction do to the light compared to a low index of refraction? What is the difference between light hitting an air-glass boundary and light hitting a glass-air boundary? Can you find an angle of total reflection when all the light reflects and none transmits?

REVISE SCENE
Create optical fibers of glass by using the brush tool. Make different shapes of fibers.



RUN/INTERACT
Can the optical fiber have any shape? Do all colors of light work?

MAKE A PREDICTION
Add lasers and direct it into the fibers. Rotate the laser and investigate what happens to the light beams as it travels through the fiber. Does the beam always go through the whole length of the fiber?

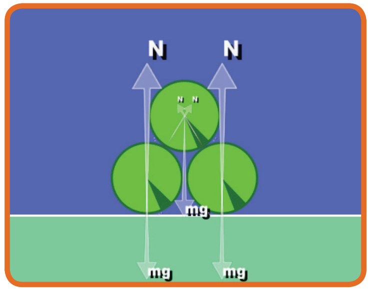
EVALUATE
Explain how the light travels through the fiber. What happens when white light is used?

20. MARBLE PYRAMID (AGES 11-14)

Target	Teacher ages 11-14 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	In this lesson the students will investigate the forces that are interacting in a marble pyramid, like friction and normal forces. Assign different material to the pyramid in order to investigate the influence of friction upon the stability. Choose different materials when creating marbles.
Learning objectives	Have a basic understanding of how static forces interact. Understand that different materials have different coefficient of friction.
Time frame	30 – 60 min
Keywords	Friction, normal force
In class	Discuss how it is possible to build a pyramid of marbles. What properties hold the pyramid together? Let the students come up with suggestions. Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation.

CREATE SCENE

Create a small pyramid using three circles.
Turn on force visualization.

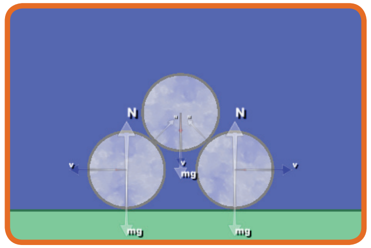


MAKE A PREDICTION

Will the pyramid collapse?
What forces are involved?

RUN/INTERACT

Start the simulation and study what forces that are involved. Assign different materials having different friction coefficients to the pyramid and watch what happens?

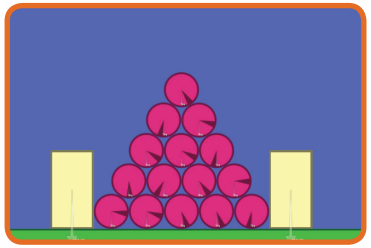


EVALUATE

What material or friction coefficient did you assign to the marbles? Why?
How did you do to make the pyramid collapse? Why?

REVISE SCENE

Create a large pyramid using marbles of the same size.



MAKE A PREDICTION

What material would be good for a marble pyramid?
How high can the pyramid be built?
Where does the pyramid start collapsing?

RUN/INTERACT

Start the simulation. Assign different materials to the pyramid and investigate whether it collapses or not. Try different materials/friction coefficient to build an as high pyramid as possible.

EVALUATE

What material did you choose for the different pyramids? Why?

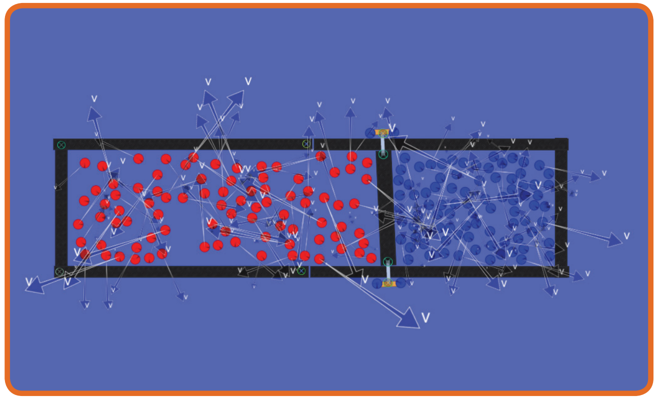
21. GAS (AGES 11-14)

Target	Teacher ages 11-14 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	This lesson allows the student to model a gas as a system of light circular solid objects kept in a container. This simple system can be used to gain understanding of abstract yet common concepts like pressure, temperature, heat conduction and insulation.
Learning objectives	Build a mental picture for temperature, heat and pressure based on particle system. Understand isolation and heat conduction through the particle model. Make prediction, setup a simple test and evaluate the results.
Time frame	30 – 60 min
Keywords	Gas, pressure, temperature, heat conduction, insulation
In class	Discuss what makes a balloon expand when you blow it up. Why is it difficult to compress the balloon. Ask if anyone has experience of what happens if you bring the balloon into a cold environment? What happens when it is brought back to a warm environment? This applies also to solids, although the particles are more tightly coupled. Discuss also the phenomena of heat conduction, e.g., how heating one end of a metal spoon eventually results in a raised temperature at the other end. Discuss strategies for isolating the handle of the spoon from its head. Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate**. Allow the students to follow-up and share their experiences in class after the simulation.

CREATE A SCENE*

Create a container made of four fixed walls and a movable inner wall. Create a circular particle and give it a light mass. Set the restitution (bounciness) of the walls and particle to 1. Make copies of the particle to fill the container.

*Creating this scene requires switching to “medium mode” in the options panel. This give access to a few more tools and settings. Furthermore, it is practical to turn gravity off in this lesson. You find this in the menu Options -> Simulation.



MAKE A PREDICTION

What happens to the gas as you move the wall towards one of the side-walls? One of the gases is now heated to a higher temperature. What effect does the gas have on the movable wall if you let it go? What will happen if the inner wall is deleted?

RUN/INTERACT

Run the simulation and interact with it.

EVALUATE

Observe that the heated gas pushes the movable wall - as do particles in a balloon. After the inner wall is removed, observe how the high velocities are being redistributed from being focused to one part of the container to become evenly distributed. This is heat conduction. The result is an even temperature. Based on these observations, how can an insulating wall be realized in reality? Try to replicate this in the simulation.
A solid can be modeled as system of particles connected by springs in a regular pattern. If you have time - model this as well and study its behaviour. You may observe both thermal vibrations and collective waves (sound waves).

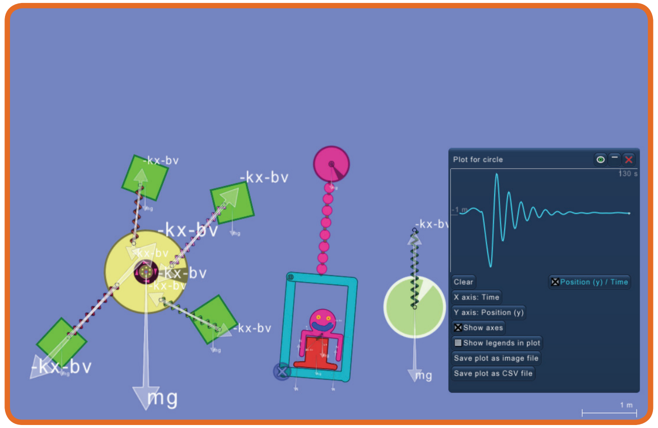
22. SPRINGS (AGES 11-14)

Target	Teacher ages 11-14 This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	Springs are used in various mechanical devices to give flexibility. Springs can also be used as a tool for measuring forces - in which case it is called a Newton Meter. This lessons allows the student to study the basic behavior of springs and to construct a force meter to examine the forces in different systems. Springs also serves as a mental picture for understanding and predicting forces, e.g. “If I attach a weight to the system with a spring, will it be stretched or pulled as the system moves?”.
Learning objectives	Understand the spring force and the oscillatory motion of objects connected to springs. Knowledge about the relation between force and change in motion. Build a mental picture for forces based on springs. Construct and use a (virtual) device for measuring force.
Time frame	45 – 60 min
Keywords	Spring, force, oscillation, g-force
In class	Discuss springs in the class. There is a relation between how much force you pull with and how stretched the spring becomes. If you hang 1 kg and the spring stretches one centimeter it will stretch 2 centimeters if you hang 2 kilos etc. If the spring is stretched 4 meters, what is the weight? Some spiral springs are constructed so that they can be both compressed (pushed) and stretched (pulled). Discuss the concept of energy stored in a compressed or stretched spring. A body hanging in an ‘ideal‘ spring can oscillate forever. Real springs are damped by internal friction (causes heating of the spring) and the oscillation damps out. Let the students build springs in Algodoo and study their behaviour. Let the students construct a virtual force measurement device and study the force in various cases, e.g. an elevator.

CREATE A SCENE*

Experiment first with hanging an object in a spring. Study the motion for different values of object mass (material) and spring stiffness and damping. Mark the object and click “Show plot” to get a graph of the motion over time Let the students design a force-meter for measuring the force in a simple elevator - or a carousel.

* Creating this scene requires switching to “medium mode” in the options panel. This give access to a few more tools and settings.



MAKE A PREDICTION

Let the students make a prediction of what the force will be like in an elevator. What will it be when it starts to move downwards and upwards? What is the motion when the elevator moves at constant velocity? You can also examine the forces in a carousel.

RUN/INTERACT

Run the simulation and interact with it.

EVALUATE

Was the direction of the force as expected? How does this correspond to what you feel in an elevator/carousel.

23. ARCH CONSTRUCTIONS (AGES 14-)

Target	Teacher ages 14- This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	In ancient times - before steel and concrete - heavy buildings and constructions were realized using arches and vaults. The stability mechanism is that heavy weight of the construction makes the pressure force between the arch blocks really large. This in turns makes the friction force very large (recall that the friction force depends on the force an object is pressed onto a surface). The friction force becomes so large that the arch blocks can't slide and the construction becomes stable. This lesson allows the student to experiment with arch design of bridges. As a final task the student should demonstrate that a simple car can safely travel over the bridge.
Learning objectives	Knowledge of arch architecture and construction stability. Understand the material properties that are important for arch stability. By successive experiments test and improve their construction design to a functioning arch.
Time frame	45 – 60 min
Keywords	Friction, arch
In class	Let the students study some examples of ancient arch constructions, e.g., for supporting a roof or a bridge. Not that rocks of large dimension could not be produced or lifted. Let the students think of different designs of constructing a bridge from many small rocks using no concrete or nails. Let the students experiment with these using Algodoo. What conclusions can be drawn regarding shapes and materials of the building elements? Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate.** Allow the students to follow-up and share their experiences in class after the simulation

CREATE A SCENE

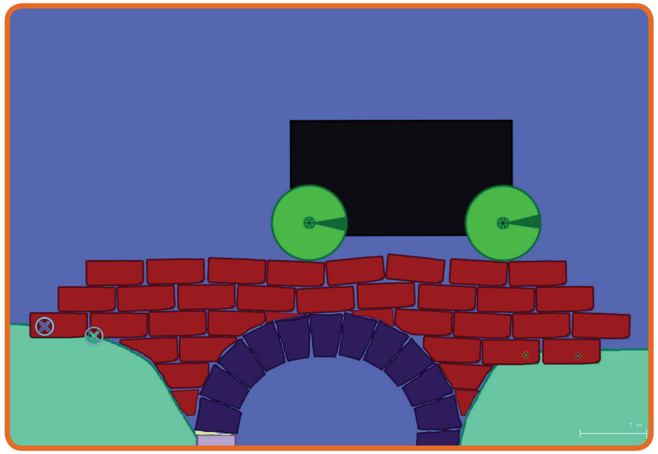
Create a ground plane and building block elements. Experiment with different shapes and materials (mass density and friction). The sculpturing tool is great for cutting the blocks into a shape that fits.

MAKE A PREDICTION

What shape and material will be important for a stable arch bridge?

RUN/INTERACT

Run the simulation and interact with it. Drive a simple vehicle over the bridge or drop a heavy load on it.



EVALUATE

What shapes and materials were most successful? Why is that?
What is the mechanism behind the stability? Force visualization helps to understand.
Can the design be improved further? How?

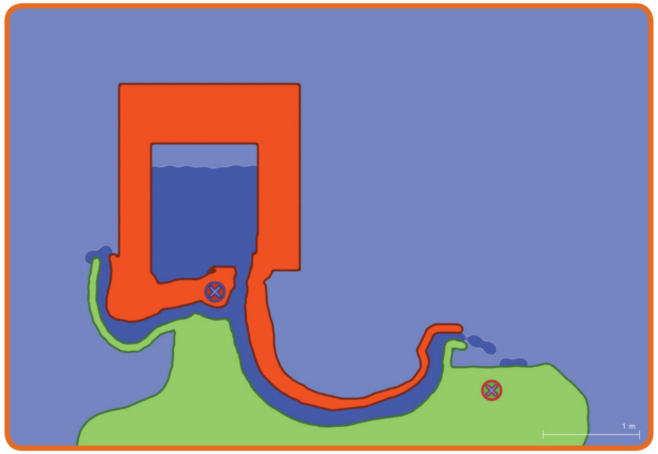
24. WATER TOWER (AGES 14-)

Target	Teacher ages 14- This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	Most water supply systems are pressurized. This is accomplished by keeping the water elevated in “water towers” and using the waters own weight for building up pressure. This lesson allows the student to understand the transportation of water through such a system and understand that there is a relation between pressure, height of the “water pillar” and flow velocity at the outlet. The pressure of the water can be observed indirectly by attaching a plug at the outlet with a spring.
Learning objectives	Pressurized water supply system. Find the important parameters by experimentation. Relation between water pressure, pipe dimension and flow velocity.
Time frame	45 - 60 min
Keywords	Water, hydraulics, pressure, flow
In class	Start by examining a real water tower and water supply system. What is the maximum height difference in the system. Let the student model a water tower, pipe and outlet in Algodoo. Let them experiment with different dimensions of the water tower, pipe and outlet. Why are water tower always placed at a high point in the area? Discuss how this can be visualized and explored in Algodoo. Let the students create scenes in Algodoo using the suggestions you came up with together or let them use their own ideas. Help the students make decisions and ask guiding questions. Encourage the students to follow the procedure **Create – Predict – Interact – Evaluate.** Allow the students to follow-up and share their experiences in class after the simulation.

CREATE A SCENE*

Create an elevated fluid container (water tower) with a hole in the bottom. Draw pipes from the bottom to the desired outlet point. Add fluid to the container, e.g., create a box and liquify it. The pressure of the water can be observed indirectly by attaching a plug at the outlet with a spring .

*Too many fluid “particles” make the simulation slow. Keep the size of the system (width and height) to about 10 meter to avoid this. Too small dimension of the pipes make the particles “tunnel”. Use thick enough walls to prevent this.



MAKE A PREDICTION

What are the important parameters for the water pressure at the outlet?
A) The height of a filled water tower.
B) The width of a filled water tower.
C) The length of the pipes.
D) The height difference between the outlet and the water tower?

RUN/INTERACT

Run the simulation and interact with it.

EVALUATE

Explain the outcome of your tests. Why are water tower always placed at a high point in the area?

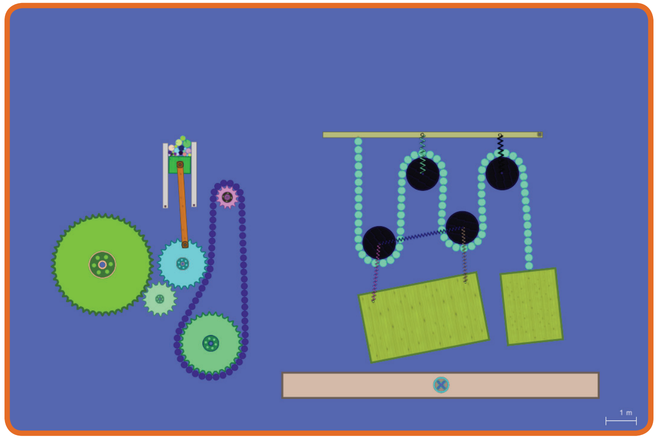
25. GEARS AND CHAINS, ROPES AND PULLEYS(AGES 14-)

Target	Teacher ages 14- This lesson plan is not intended to be handed out to students but to be used as a teacher preparation and tutorial.
Description	Conversion between angular and linear motion and transmission of force and torque over distances is practical in many situations. This can be realized with gears, chains, rods, rope and pulleys. This lesson allows the student to construct both simple and complicated systems for converting motion and transmitting force. The technique is applied to realizing a mechanical machine designed by the students.
Learning objectives	Conversion between linear and rotational motion Gears and mechanical advantage Force and torque transmission Design for a purpose Evaluate a construction from a design criteria
Time frame	45 - 60 min
Keywords	Motion conversion, force transmission, gears, chain, rope, pulley, hydraulics
In class	Discuss examples of systems that involves conversion between linear and rotational motion. Discuss systems that involves force transmission over short and long distances. What forms of force transmission do you know of? What is the purpose of having gears? When are pulleys used? Let the students invent a mechanical device for some specific purpose that involves gears and chains or rope and pulleys - it might be a replica of some existing device or pure fantasy. Make a design for the device and build a simulation. Let the students evaluate the device with respect to the purpose of it. What modifications can be done. Let the students present their results.

CREATE A SCENE
Explore the tools for making gears and chains - rope and pulleys. Make simple systems that transmit force and torque and convert between linear and rotational motion. Use a hinge motor to drive the system - or use the gravitational pull. Observe the effect on motion and force of changing the gear size and number of pulleys.

DESIGN A SYSTEM*
Create a mechanical device for some specific purpose that involves gears and chains or rope and pulleys. It might be a replica of some existing or historical device or pure fantasy.

*Pure 2D has some restrictions. If you try to make a bicycle with chains and gears you may find that these collide with the wheels. The solution in Algodoo is to use different “collision layers” for different parts. You find this functionality after switching to “medium mode”.



RUN/INTERACT
Run the simulation and interact with it.

EVALUATE
Does the device operate as you planned? Can it be modified to be improved?

PRINT AND DESIGN YOUR OWN LESSON PLAN

Target	
Description	
Learning objectives	
Time frame	
Keywords	
In class	

CREATE A SCENE

MAKE A PREDICTION

RUN/INTERACT

EVALUATE

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