2D Multibody Dynamics with

ESME sudria
Lille - Paris - Lyon

ALGODOO is a 2D-simulation environment for creating interactive scenes and making use of the physics that explains our real world. The main use of ALGODOO is structural dynamics simulation in two dimensions. Fluid-dynamics and fluid-structure interaction is also possible. However, Algodoo is meant to be a multibody simulator: that's mean fluid-dynamics is "particle based" instead of "volume based", i.e. less accurate but computationally efficient.

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.

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.

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.

FEW TIPS BEFORE YOU START…

ALGODOO is a powerful tool, however is not meant to be a professional multibody dynamics simulator.

Optimal design always starts with paper and pencil.

Precise sketching is not possible within **ALGODOO**. However, sketches from CAD software can be imported. The procedure for importing from FreeCAD, CATIA or Solidworks is not automated:

1) Within the CAD software, be sure to have a clean view of the face you want to import (no centreline or axis, or any other element then the face)
2) Set the background color to white
3) Screenshot the image and save it with an image editor (like Paint).
4) Drag & drop the image in **ALGODOO**.

ALGODOO represents the world in 2D, however each shape in the scene has a mass: it means that a conventional thickness is defined. Be aware of that!

ALGODOO can measure velocity, displacement, acceleration, forces, and momentums, kinetic and potential energy. Again, make the difference between 2D shapes and masses.

In order to measure the speed of a specific point you have to create a new geometric element (a small circle with minimal mass, i.e. a point), and stick it to the element of your choice. You can also track the position of this point on the screen.

There are some tutorials on the web. First of all, be sure to complete the first tutorial on **ALGODOO**.

HOW TO TRANSFORM A ROTATORY MOTION INTO LINEAR MOTION (MICROMOTOR)

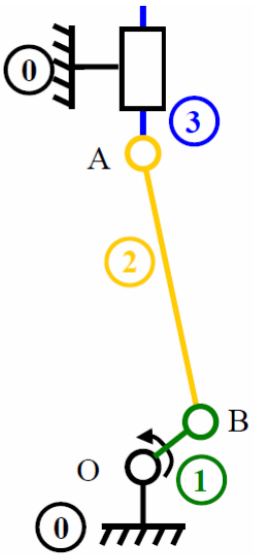
The objective of this tutorial is the realization of the system studied in the course of cinematic. Here is the sketch of the system:

We are going to realise this mechanism with Algodoo. Real motors have a massive element (most of the times a flywheel) instead of the linear element OB, so that vibration can be minimised.

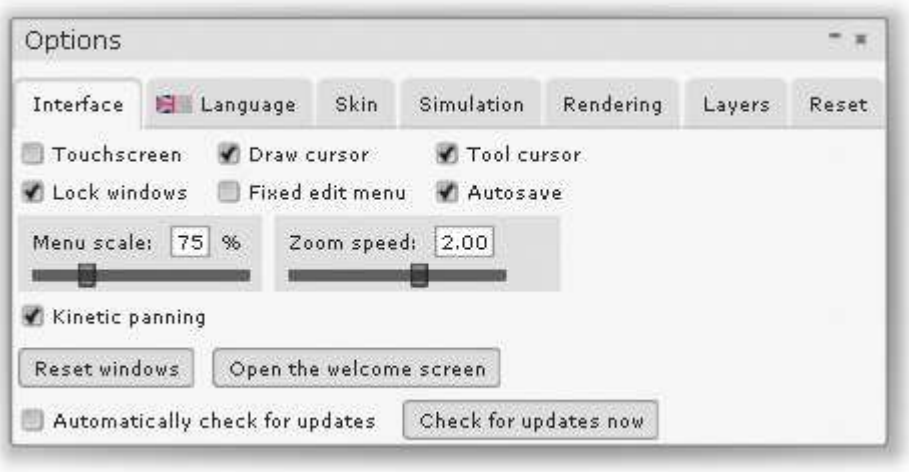
Exemple du micromoteur

Données d'entrées :
→ Vitesse de rotation de la manivelle par rapport au bâti 0 (100 tr/min)
→ Rayon OB=3cm
→ Echelle des vitesses de 1cm pour 1m/s.

Objectif :
→ Déterminer la vitesse de sortie du piston 3 par rapport au bâti 0.



1) Open Algodoo and create a new scene. Let's choose the Black template.
2) Delete the Semi-infinite plane: we don't need it.
3) Select options (up to the left) and be sure you've this configuration:



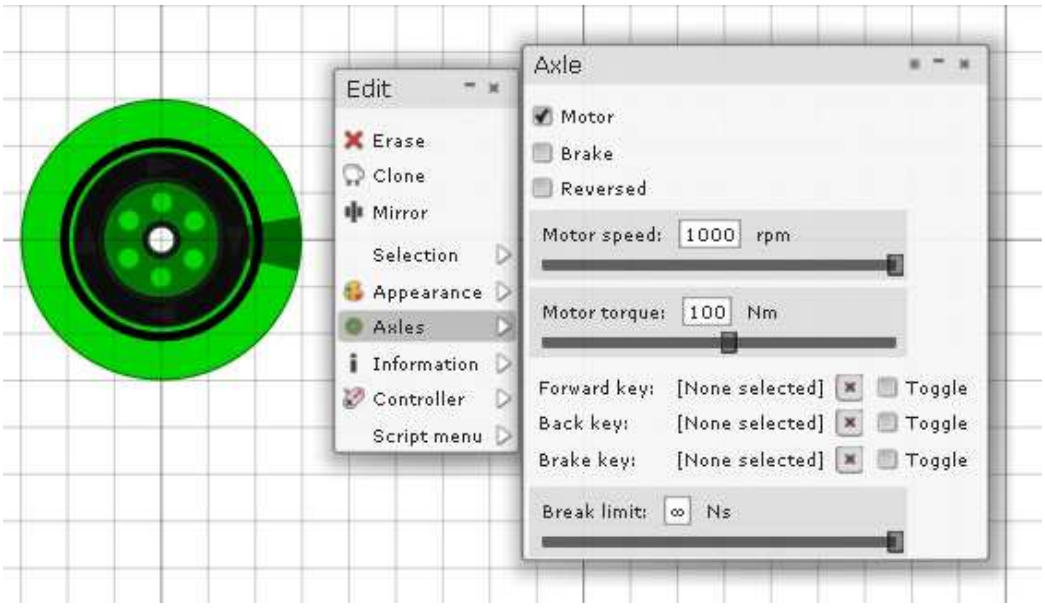
This will ensure a smooth simulation. For other application a different frequency should be used. In fluid-dynamic simulations, compressible fluid modelling uses a lot of CPU.

5) Turn gravity and air friction off, grid on

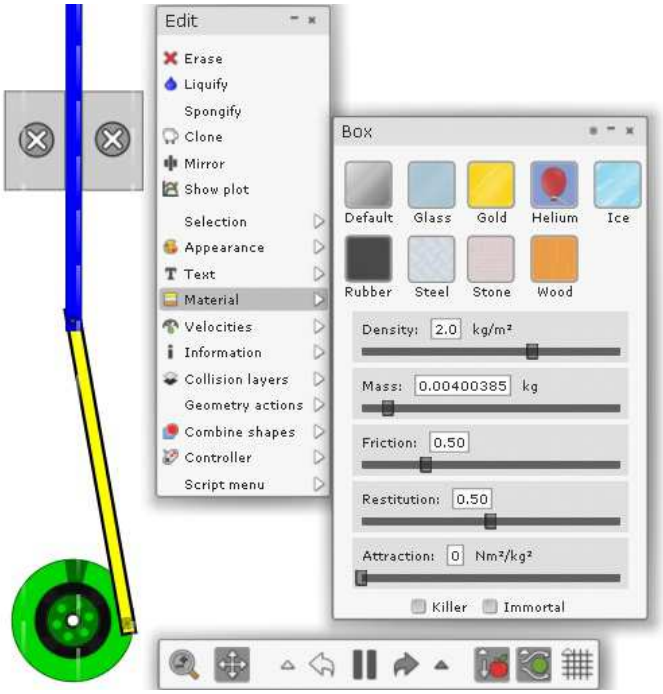
6) Set zoom to 20. This is the maximum zoom in Algodoo. However, if you need to use microns instead of meters, you can still use meters and scale material properties (such as densities). For this application, a zoom set to 20 is ok.

7) Select Snap to grid on the grid icon and create the flywheel, a 4 cm circle obtained with the circular shape tool; then colour it in green, in analogy with the sketch at the beginning of this tutorial. For doing that, right-click on the flywheel and the edit menu appears. The edit menu is probably the most important tool in Algodoo. You can change the colour of the shape with Appearance.

8) Save your scene (frequent saving is a good practice!) and add an axle to the centre of the flywheel. Right-click on the axle and set it as a motor with 100 rpm of speed.



9) Add thickness to the flywheel. Algodoo is a 2D simulation software, but for getting real results you have to set a thickness to each component. Right-click on the flywheel, select script menu and set zDepth (the last setting in this menu) to 10 mm, that is a reasonable value.



10) Create a yellow rod: 200 mm of length, 10 mm of width, 10 mm of thickness. Use the axle tool to fix the rod to the flywheel.

11) Create a blue rod: 200 mm of length, 10 mm of width, 10 mm of thickness. Use the axle tool to fix the blue rod to the yellow rod.

12) Create two grey boxes for constraining the blue rod. Dimensions are not important.

13) Right click on each element and check the materials. Each element is made of steel: find on the internet the steel density, calculate the volume of each element and select in Algodoo the right mass. Also select the friction coefficient for lubricated steel to steel parts.

14) We have to track the kinematics of the problem. Draw a red circle with the circle tool, the use the scale tool to reduce the circle to a point. Right click on the red point and reduce the mass to zero. Finally, place it at the end of blue rod and use the fixate tool. Then right click on the fixate tool. On “selection”, click on “move to the back”.

15) Right click on the red point, and select “show plot”. Be careful, don’t select the entire blue rod! If you run the simulation, the speed of the red point as a function of time will be plotted. The data are exportable in CSV format. You may click on “visualization” on the right side of the screen and show the forces in the model, including the friction force.

This is the end of the first tutorial on Algodoo. Feel free to take measurements, visualizations and modify the system as you wish.