CINEMA 4D

Release 9

Dynamics

Dynamics

Programming Team	Christian Losch, Philip Losch, Richard Kurz, Tilo Kühn, Thomas Kunert, David O'Reilly, Cathleen Poppe.
Plugin Programming	Sven Behne, Wilfried Behne, Michael Breitzke, Kiril Dinev, Per-Anders Edwards, David Farmer, Jamie Halmick, Richard Hintzenstern, Jan Eric Hoffmann, Eduardo Olivares, Nina Ivanova, Markus Jakubietz, Eric Sommerlade, Hendrik Steffen, Jens Uhlig, Michael Welter, Thomas Zeier.
Product Manager	Marco Tillmann.
QA Manager	Björn Marl.
Writers	Paul Babb, Rick Barrett, Oliver Becker, Jens Bosse, Chris Broeske, Chris Debski, Glenn Frey, Michael Giebel, Jason Goldsmith, Jörn Gollob, Sven Hauth, Josiah Hultgren, Arndt von Königsmarck, David Link, Arno Löwecke, Aaron Matthew, Josh Miller, Matthew 'Mash' O'Neill, Janine Pauke, Marcus Spranger, Luke Stacy, Perry Stacy, Marco Tillmann, Jeff Walker, Scot Wardlaw.
SDK Docs & Support	David O'Reilly, Mikael Sterner.
Layout	Oliver Becker, Harald Egel, Michael Giebel, David Link, Luke Stacy, Jeff Walker.
Translation	Oliver Becker, Michael Giebel, Arno Löwecke, Björn Marl, Josh Miller, Janine Pauke, Luke Stacy, Marco Tillmann, Scot Wardlaw.

MAXON Computer End User License Agreement

NOTICE TO USER

WITH THE INSTALLATION OF DYNAMICS (THE “SOFTWARE”) A CONTRACT IS CONCLUDED BETWEEN YOU (“YOU” OR THE “USER”) AND MAXON COMPUTER GMBH (THE “LICENSOR”), A COMPANY UNDER GERMAN LAW WITH RESIDENCE IN FRIEDRICHSDORF, GERMANY.

WHEREAS BY USING AND/OR INSTALLING THE SOFTWARE YOU ACCEPT ALL THE TERMS AND CONDITIONS OF THIS AGREEMENT. IN THE CASE OF NON-ACCEPTANCE OF THIS LICENSE YOU ARE NOT PERMITTED TO INSTALL THE SOFTWARE.

IF YOU DO NOT ACCEPT THIS LICENSE PLEASE SEND THE SOFTWARE TOGETHER WITH ACCOMPANYING DOCUMENTATION TO MAXON COMPUTER OR TO THE SUPPLIER WHERE YOU BOUGHT THE SOFTWARE.

1. General

Under this contract the Licensor grants to you, the User, a non-exclusive license to use the Software and its associated documentation. The Software itself, as well as the copy of the Software or any other copy you are authorized to make under this license, remain the property of the Licensor.

2. Use of the Software

You are authorized to copy the Software as far as the copy is necessary to use the Software. Necessary copies are the installation of the program from the original disk to the mass storage medium of your hardware as well as the loading of the program into RAM.

(2) Furthermore the User is entitled to make a backup copy. However only one backup copy may be made and kept in store. This backup copy must be identified as a backup copy of the licensed Software.

(3) Further copies are not permitted; this also includes the making of a hard copy of the program code on a printer as well as copies, in any form, of the documentation.

3. Multiple use and network operation

(1) You may use the Software on any single hardware platform, Macintosh or Windows, and must decide on the platform (Macintosh or Windows operating system) at the time of installation of the Software. If you change the hardware you are obliged to delete the Software from the mass storage medium of the hardware used up to then. A simultaneous installation or use on more than one hardware system is not permitted.

(2) The use of the licensed Software for network operation or other client server systems is prohibited if this opens the possibility of simultaneous multiple use of the Software. In the case that you intend to use the Software within a network or other client server system you should ensure that multiple use is not possible by employing the necessary access security. Otherwise you will be required to pay to the Licensor a special network license fee, the amount of which is determined by the number of Users admitted to the network.

(3) The license fee for network operation of the Software will be communicated to you by the Licensor immediately after you have indicated the number of admitted users in writing. The correct address of the Licensor is given in the manual and also at the end of this contract. The network use may start only after the relevant license fee is completely paid.

4. Transfer

(1) You may not rent, lease, sublicense or lend the Software or documentation. You may, however, transfer all your rights to use the Software to another person or legal entity provided that you transfer this agreement, the Software, including all copies, updates or prior versions as well as all documentation to such person or entity and that you retain no copies, including copies stored on a computer and that the other person agrees that the terms of this agreement remain valid and that his acceptance is communicated to the Licensor.

(2) You are obliged to carefully store the terms of the agreement. Prior to the transfer of the Software you should inform the new user of these terms. In the case that the new user does not have the terms at hand at the time of the transfer of the Software, he is obliged to request a second copy from the Licensor, the cost of which is born by the new licensee.

(3) After transfer of this license to another user you no longer have a license to use the Software.

5. Updates

If the Software is an update to a previous version of the Software, you must possess a valid licence to such previous version in order to use the update. You may continue to use the previous version of the Software only to help the transition to and the installation of the update. After 90 days from the receipt of the update your licence for the previous version of the Software expires and you are no longer permitted to use the previous version of the Software, except as necessary to install the update.

6. Recompilation and changes of the Software

(1) The recompilation of the provided program code into other code forms as well as all other types of reverse engineering of the different phases of Software production including any alterations of the Software are strictly not allowed.

(2) The removal of the security against copy or similar safety system is only permitted if a faultless performance of the Software is impaired or hindered by such security. The burden of proof for the fact that the performance of the program is impaired or hindered by the security device rests with the User.

(3) Copyright notices, serial numbers or other identifications of the Software may not be removed or changed. The Software is owned by the Licensor and its structure, organization and code are the valuable trade secrets of the Licensor. It is also protected by United States Copyright and International Treaty provisions. Except as stated above, this agreement does not grant you any intellectual property rights on the Software.

7. Limited warranty

(1) The parties to this agreement hereby agree that at present it is not possible to develop and produce software in such a way that it is fit for any conditions of use without problems. The Licensor warrants that the Software will perform substantially in accordance with the documentation. The Licensor does not warrant that the Software and the documentation comply with certain requirements and purposes of the User or works together with other software used by the licensee. You are obliged to check the Software and the documentation carefully immediately upon receipt and inform the Licensor in writing of apparent defects 14 days after receipt. Latent defects have to be communicated in the same manner immediately after their discovery. Otherwise the Software and documentation are considered to be faultless. The defects, in particular the symptoms that occurred, are to be described in detail in as much as you are able to do so. The warranty is granted for a period of 6 months from delivery of the Software (for the date of

which the date of the purchase according to the invoice is decisive). The Licensor is free to cure the defects by free repair or provision of a faultless update.

(2) The Licensor and its suppliers do not and cannot warrant the performance and the results you may obtain by using the Software or documentation. The foregoing states the sole and exclusive remedies for the Licensor’s or its suppliers’ breach of warranty, except for the foregoing limited warranty. The Licensor and its suppliers make no warranties, express or implied, as to noninfringement of third party rights, merchantability, or fitness for any particular purpose. In no event will the Licensor or its suppliers be liable for any consequential, incidental or special damages, including any lost profits or lost savings, even if a representative of the Licensor has been advised of the possibility of such damages or for any claim by any third party.

(3) Some states or jurisdictions do not allow the exclusion or limitation of incidental, consequential or special damages, or the exclusion of implied warranties or limitations on how long an implied warranty may last, so the above limitations may not apply to you. In this case a special limited warranty is attached as exhibit to this agreement, which becomes part of this agreement. To the extent permissible, any implied warranties are limited to 6 months. This warranty gives you specific legal rights. You may have other rights which vary from state to state or jurisdiction to jurisdiction. In the case that no special warranty is attached to your contract please contact the Licensor for further warranty information.

The user is obliged to immediately inform the transport agent in writing of any eventual damages in transit and has to provide the licensor with a copy of said correspondence, since all transportation is insured by the licensor if shipment was procured by him.

8. Damage in transit

You are obliged to immediately inform the transport agent in writing of any eventual damages in transit and you should provide the Licensor with a copy of said correspondence, since all transportation is insured by the Licensor if shipment was procured by him.

9. Secrecy

You are obliged to take careful measures to protect the Software and its documentation, in particular the serial number, from access by third parties. You are not permitted to duplicate or pass on the Software or documentation. These obligations apply equally to your employees or other persons engaged by you to operate the programs. You must pass on these obligations to such persons. You are liable for damages in all instances where these obligations have not been met. These obligations apply equally to your employees or other persons he entrusts to use the Software. The User will pass on these obligations to such persons. You are liable to pay the Licensor all damages arising from failure to abide by these terms.

10. Information

In case of transfer of the Software you are obliged to inform the Licensor of the name and full address of the transferee in writing. The address of the Licensor is stated in the manual and at the end of this contract.

11. Data Protection

For the purpose of customer registration and control of proper use of the programs the Licensor will store personal data of the Users in accordance with the German law on Data Protection (Bundesdatenschutzg esetz). This data may only be used for the above-mentioned purposes and will not be accessible to third parties. Upon request of the User the Licensor will at any time inform the User of the data stored with regard to him.

12. Other

(1) This contract includes all rights and obligations of the parties. There are no other agreements. Any changes or alterations of this agreement have to be performed in writing with reference to this agreement and have to be signed by both contracting parties. This also applies to the agreement on abolition of the written form.

(2) This agreement is governed by German law. Place of jurisdiction is the competent court in Frankfurt am Main. This agreement will not be governed by the United Nations Convention on Contracts for the International Sale of Goods, the application of which is expressly excluded.

(3) If any part of this agreement is found void and unenforceable, it will not affect the validity of the balance of the agreement which shall remain valid and enforceable according to its terms.

13. Termination

This agreement shall automatically terminate upon failure by you to comply with its terms despite being given an additional period to do so. In case of termination due to the aforementioned reason, you are obliged to return the program and all documentation to the Licensor. Furthermore, upon request of Licensor you must submit written declaration that you are not in possession of any copy of the Software on data storage devices or on the computer itself.

14. Information and Notices

Should you have any questions concerning this agreement or if you desire to contact MAXON Computer for any reason and for all notifications to be performed under this agreement, please write to:

MAXON Computer GmbH
Max-Planck-Str. 20
D-61381, Friedrichsdorf
Germany

or for North and South America to:

MAXON Computer, Inc.
2640 Lavery Court Suite A
Newbury Park, CA 91320
USA

or for the United Kingdom and Republic of Ireland to:

MAXON Computer Ltd
The Old School, Greenfield
Bedford MK45 5DE
United Kingdom

We will also be pleased to provide you with the address of your nearest supplier.

Contents

Introduction

With Dynamics you will soon be creating stunningly realistic animation that would be almost impossible to achieve using the traditional keyframe approach.

Thank you for purchasing Dynamics, the ultimate CINEMA 4D module for creating the realistic motion of interacting objects. With Dynamics you will be able to simulate real-world motion, apply real-world forces like wind and gravity, apply friction, detect collisons and much more. You will also be able to combine dynamics with traditional keyframe animation.

This manual is divided into a tutorial section and a reference section. Dynamics is by definition a fairly complex subject, it is literally chaos, so in order to get a feel for Dynamics we recommend you work through the tutorials in the order they appear in this manual and, if something isn't clear, look it up in the reference for a full description.

Dynamics is a powerful beast and it will require some taming; but, once controlled, it will save you much time and enrich your animations with a realism that is almost impossible to achieve using keyframes.

Registration

Registering your Dynamics module is extremely important. The serial number included with your Dynamics package is temporary and it will expire three months after the module's installation. To receive your final serial number, you must register. So please fill in and return the registration form at the earliest opportunity.

Registering your Dynamics module will also entitle you to free technical support via telephone, fax and email. And by checking the appropriate box on the registration form, MAXON will keep you informed of the latest product information and updates.

Please note that you can also register online at www.maxon.net, MAXON's homepage.

Installation

To install Dynamics, run the installation program and follow the on-screen installation instructions.

The installation program will create a Dynamics folder in your CINEMA 4D folder. The installation program will place all the CINEMA 4D Dynamics files into this Dynamics folder.

Training

Training is available for Dynamics and other MAXON products. For details, please contact MAXON or your local MAXON distributor.

Web Resources

Thousands of powerful resources are available on the web, including online tutorials, discussion lists, textures, models, galleries and information on 3D books. You will find links to a rich selection of these sites at www.maxon.net, MAXON's homepage.

One website that you may wish to bookmark is www.plugincafe.com, the home of CINEMA 4D plugins. Here you will find dozens of useful plugins, both free and commercial. For plug-in developers, there are resources, including the SDK, tutorials and a free support forum.

Lastly there is the MAXON website itself, www.maxon.net. In addition to the links mentioned above, it is from here that you can register your MAXON product, download updates, send MAXON a suggestion, check out the gallery, learn from online tutorials and much more.

Technical Support

Your local MAXON distributor will be delighted to assist you with your technical queries for Dynamics. You are also welcome to contact MAXON directly.

Please note that you will be entitled to free technical support provided you have registered your Dynamics module (see Registration, above).

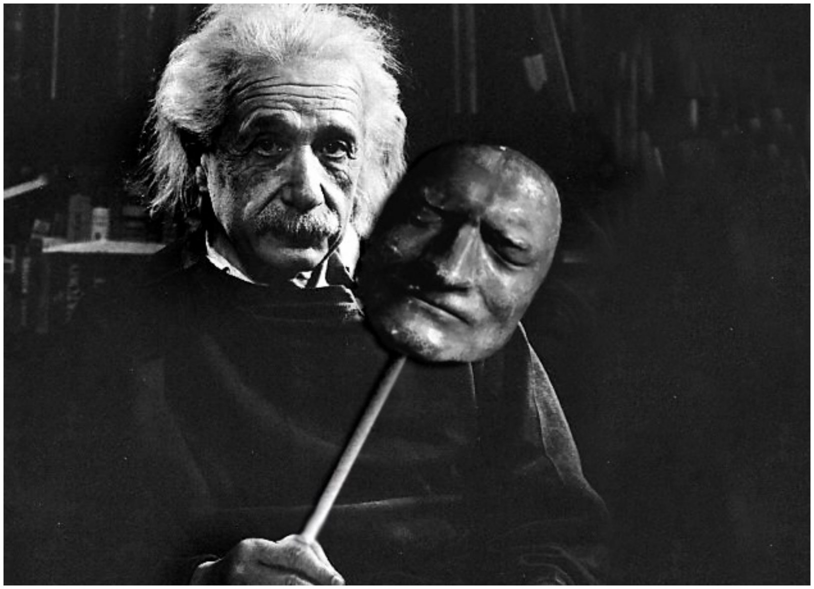
CINEMA 4D

Release 9

Dynamics Tutorials

Overview

Creating physically realistic animation by keyframing can be time-consuming. By letting Dynamics take control of the motion of objects and the interactions between them, much of that tedious work can be removed.



Dynamics enables a wide range of dynamics to be simulated. This chapter will outline the dynamics that are available, which include:

- Rigid and soft bodies
- Gravity, drag and wind
- Springs
- Collisions
- Constraints

The use of dynamics will be outlined, giving some ideas of how each area can be used to create various types of simulation.

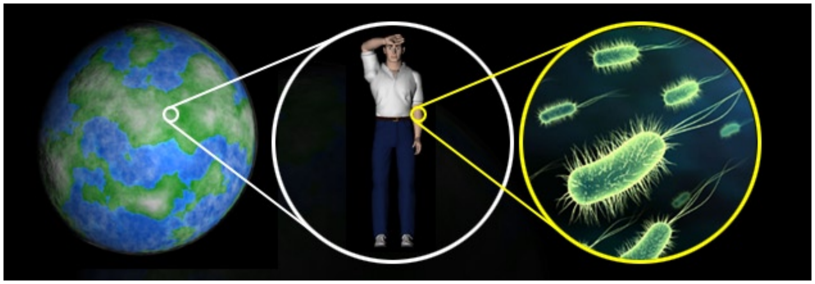
Simulating real world dynamics can be computationally expensive and has some limitations which must be overcome by art rather than science. The advantages of using simulation over traditional keyframing for motion and object interaction means that once you have a simulation environment created you can move and alter objects without needing to keyframe the whole sequence again.

Although the advantages are powerful, to prevent wasted time during the development of an animation that uses Dynamics you must be aware of the limitations.

Limitations

Calculations on current computer systems are subject to inaccuracies and numerical size limits, and although Dynamics does a great job of overcoming these problems, you may find that you occasionally need to alter values and options to assist it.

Using extreme scales is not recommended as this would give Dynamics some phenomenal numbers to calculate.



Real world physical values range from the incredibly small to the extremely large. Trying to represent this vast range of values within a computer would require a very powerful system and would make simulation unusable for serious animation work. The solution adopted in Dynamics is to use no physically meaningful values, even though the dynamics of Dynamics does give truly realistic appearing dynamics.

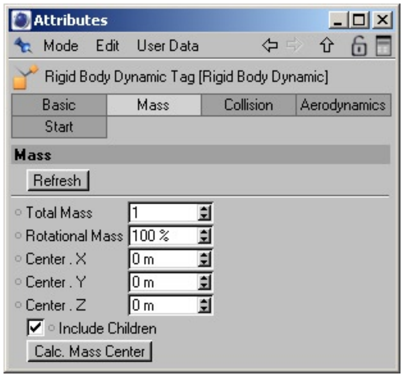
This means that you enter values according to your scene and how you want the dynamics to appear. This also gives you the artistic freedom to create scenes that do not strictly adhere to real world dynamics.

The standard sizes and values used in CINEMA 4D work best with Dynamics values close to 1. Making your scene smaller in scale will tend to mean making the Dynamics values lower, and scaling up your scene will tend to mean having larger Dynamics values. The actual values themselves depend on the interactions you want to achieve; the tutorials in this manual will help to give you a good starting point for some common values and how to adjust them to give the dynamics you want.

Rigid Bodies

The dynamics of rigid bodies is the simplest to understand and is a good starting point to begin understanding Dynamics.

Each object we want to be affected by Dynamics must have either a Soft or Rigid Body tag.



Rigid Body Dynamic Tag [Rigid Body Dynamic]

Mass

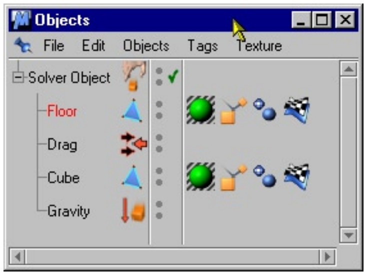
Total Mass	1
Rotational Mass	100 %
Center . X	0 m
Center . Y	0 m
Center . Z	0 m

✓ Include Children

Rigid bodies are objects which do not change their geometries during the dynamics simulation. They have properties similar to real world solid objects and will appear to interact and move just as real solid objects would.

Each rigid body has a velocity and mass; these are used by Dynamics to determine how the rigid body object interacts and moves.

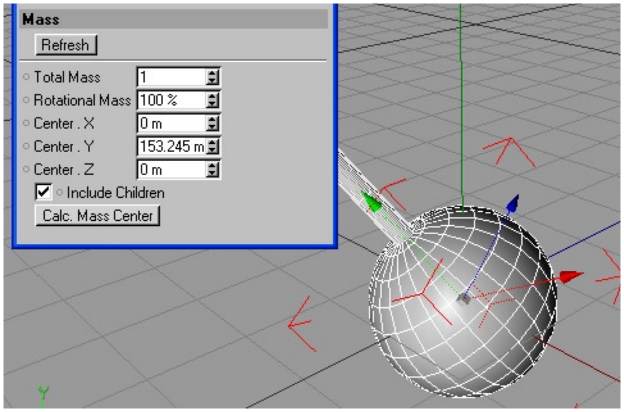
Objects we want to calculate must be children of a Solver object.



To begin a simulation you need a Solver object. This object literally solves the mathematics needed to give physically realistic motion. By placing your objects (with the relevant tags) inside the solver, you enable them to interact with the dynamics objects and to be controlled by the simulation.

The simplest starting point is to make an object move. This requires the object to have a rigid body dynamic tag, a mass and a velocity. The solver will then calculate the object's new position on each frame, which will be a straight line in the direction given by the velocity. The velocity values entered for the rigid body (Start tab in the Attribute manager) tell Dynamics how many units the object should move along each axis in one second.

The centre of mass does not have to be at the origin, we can specify an offset.


Mass

Refresh

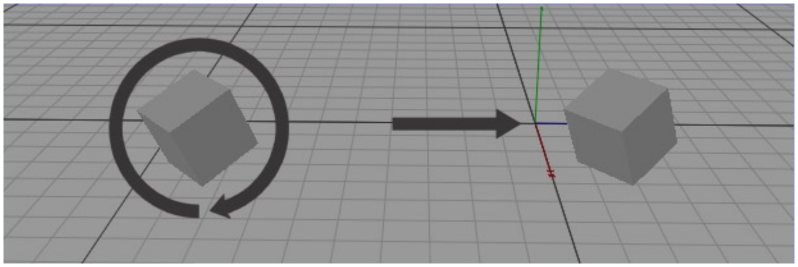
Total Mass: 1
Rotational Mass: 100 %
Center . X: 0 m
Center . Y: 153.245 m
Center . Z: 0 m
☑ Include Children

Calc. Mass Center

In a similar way to moving an object in a straight line, you can also rotate a rigid body around its centre of mass. You can place this special point anywhere you like; physically it would depend on the density and shape of an object, but here we have no need for these so Dynamics enables you to set it manually, or have it placed at the centre of the geometry. This special point is where Dynamics will check all rigid body positions and perform all interactions — this is an important point to remember.

For rotation, the values given in the Start tab for the angular velocity tell Dynamics how many degrees per second the object should rotate about each axis.

If there are no friction collisions or wind then rotation and movement are able to remain totally independent of each other.



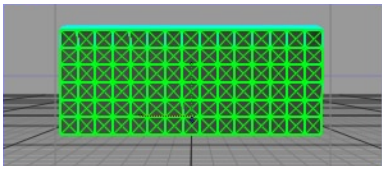
Now that we have objects moving and rotating we need to know how to change their paths and make them interact with other objects, otherwise they'll continue for as long as the simulation runs, or until their energy runs out, moving and rotating in exactly the same way. This energy loss is part of the dynamics calculations, you can turn it off if you wish to create the outer space feel, but overall a small energy loss will work to control your scene and will only slow your objects slightly.

In the real world, to change an object's motion you need to apply a force to it — hitting it in a collision, blowing it with wind, letting gravity do its thing. The same applies in Dynamics, which offers many different ways to apply forces to objects. This tutorial manual will guide you through those forces.

Soft Bodies

A soft body can be thought of as a mesh of small masses, each mass located at the points on your object. These masses can interact with the dynamics just as the centre of mass of the rigid bodies does.

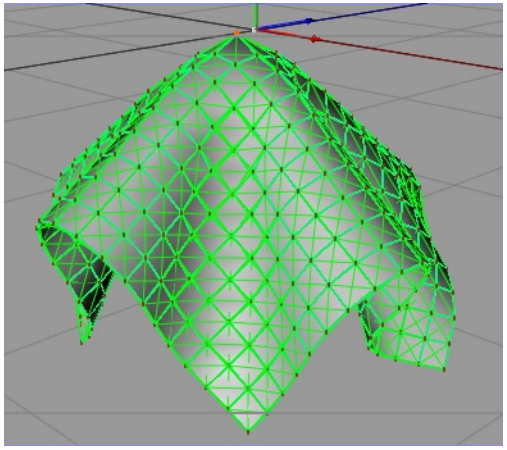
Soft Bodies are one of the most powerful features of Dynamics.



The masses associated with each point of a soft body are called soft masses and can be given a custom mass, just as rigid bodies can, enabling you to effectively change the surface density of the object.

As with rigid bodies, you can set them to have a zero mass, which prevents the dynamics from moving that mass. This is useful as a simple form of constraint for soft bodies; by setting certain soft masses to zero you can give the impression of an object being attached to something else in your scene.

We can assign weightlessness to certain points, effectively holding up an object in a certain place.



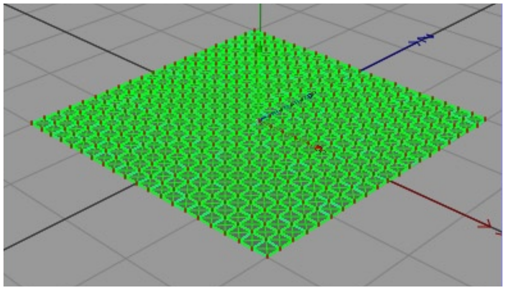
Attaching springs between the soft masses will give the object a surface structure that can control how the polygons can compress and stretch. The forces within Dynamics can affect the soft mass motion, which is then controlled by the springs on the object to give the impression of a soft structure or a material.

Creating the illusion of materials is a difficult job for keyframing. CINEMA 4D Dynamics provides you with the ability to use the power of dynamics to create the animation needed to give materials movement in a physically realistic manner. Soft body objects have their points linked by layers of springs, each type of layer (custom, structural, shear and flexion) can have its own options for the springs. These springs give the object a structure that enable it to squash and fold, unlike a rigid body which retains the same geometry throughout the dynamics simulation.

Dynamics has the ability to layer different types of springs that join different points on your surface. This layering of springs is important in creating realistic appearing materials. Items such as cloth tend to be very rigid if you try to stretch them, yet fold easily if you try to squash them.

This type of structure can be created by using structural springs to give the whole object a stiff yet flexible structure, and then by adding flexion springs you give the object the ability to fold gently rather than creasing along the lines of the polygon structure.

By adjusting the stiffness and damping of these springs you can form many different types of materials. You can also change the type of behavior of the springs so that you can permanently deform the shape as the springs are stretched or compressed; this type of behavior is known as ‘plastic’.


Virtual springs are created between certain points, these are what will give the soft material its motion.

Creating complex materials can be achieved by limiting the points to which certain springs are attached and by adjusting the soft masses of the points. Creating different types of materials is a case of trying different spring configurations and values, with a little logic applied to how they should behave.

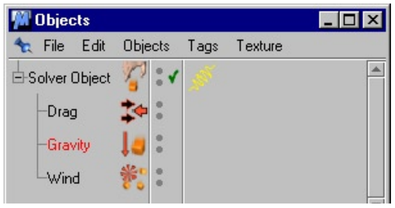
You can control the motion of the soft bodies by using a target, and this is a way of making soft bodies follow another object. You can also control how well the target object is followed, which enables you, for example, to add clothing and have it move with your character.

Damping of the springs should be used in a similar way to that in which drag is used to help Dynamics. If you use a large stiffness or low mass you may find that the points begin to vibrate wildly and may even explode the object. By adding damping and drag you can help Dynamics to control these increasing velocities and give a more controlled simulation.

Forces

To help animate real world motion, Dynamics has force objects which can cause an object's motion to change in a realistic way. These are Gravity, Drag, Wind and Springs. There are also collisions for realistic impacts between objects, and frictional forces between objects.

There are a variety of ways in which we can move and deform objects — wind, gravity, drag and springs are the most basic.



When using forces within Dynamics you may experience motion that becomes unrealistic and unpredictable, or perhaps objects which suddenly vanish from view. This is the behavior that occurs when the values within the solver become too large or too small and therefore become subject to the limitations of computation outlined above. There are a number of ways to help Dynamics overcome these limitations.

You can first try adjusting the values for your objects, making sure they're as close to 1 as possible while still giving the motion and interactions you need for your animation.

Another solution is to change the way in which the solver calculates the motion. In the real world, objects move in a continuous way, they don't jump from one position to another on a per frame basis. The Solver object can oversample between each frame to increase the accuracy of the motion and to help reduce sudden changes and inaccuracies.

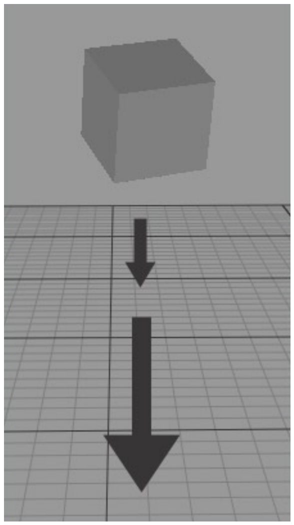
Changing the integration method (how the motion is calculated) can also help prevent sudden unrealistic changes.

Motion in the real world is also subject to many forms of energy dissipation where the energy transfers to many other forms; for example when a falling object collides with another some of its energy will dissipate to sound and heat.

Energy dissipation is also needed for realistic simulation. By using a Drag object in your solver you can gently apply a frictional type of force to your objects (similar to air resistance), giving more realistic motion and rescuing the solver from continually increasing velocities.

Gravity

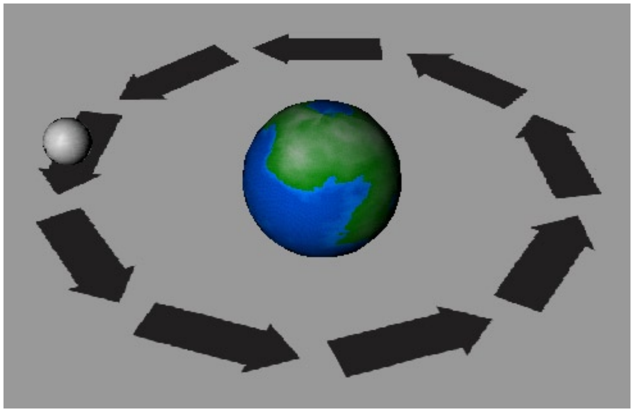
Ask most people what gravity does and they will probably say that it causes things to fall. This is a simplified view, but often in an animation all you want is for an object to fall in one direction, normally down.


Gravity can act in a single direction, such as the downward pull of the Earth.

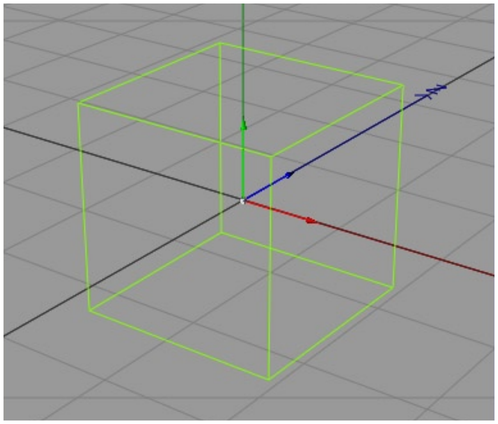
With Dynamics this type of force can be added to a simulation using an axial gravity field in the direction you wish objects to fall. By adjusting the strength and scales that you use for your objects, you can have objects falling in a way that is familiar and realistic.

Having very large scale objects will require a large gravity strength to give realistic motion, which will require more accurate, and hence slower, simulation. Keeping object scales towards the default CINEMA 4D sizes will enable you to use lower values for gravity (and all other forces) which in turn will enable you to use less accurate and faster simulation. This is a balance that you will need to find for individual scenes.

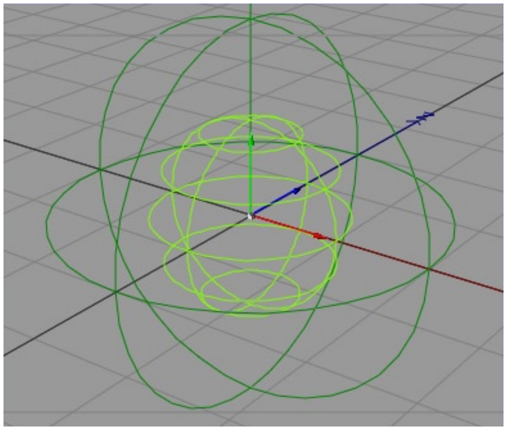
More accurately, gravity is an attractive force between any two objects with mass. In Dynamics this type of gravity is given the name Newton, after the man who discovered it and invented these simplified laws. This type of gravity can be used to give objects interactions, to either repel them from each other, or to attract. By using anti-gravity (making the strength negative, that is) you can simulate a simple type of collision — if two objects get close enough they can be repelled, which appears visually to be a collision.


Newtonian gravity is available for larger scale scenes, such as planets orbiting.

The distance over which gravity can act can be set, along with where and how strong the repulsion is for the distance the objects are apart. These types of settings are crucial for making gravity collisions work, otherwise you may find that collisions become either squishy or so strong that objects fly out of view at extraordinary speeds.

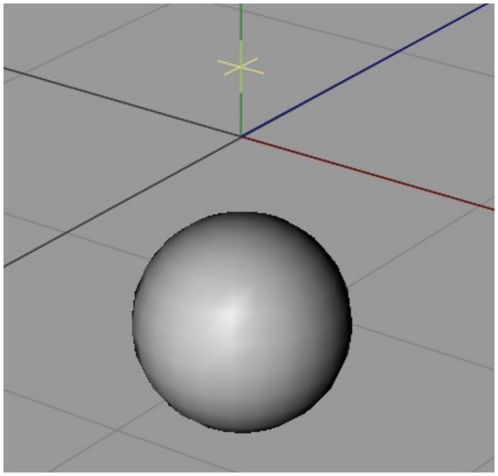

All forces can be restricted to a size and shape, anything outside of this shape will not be affected.

Further types of collisions are possible using gravity by careful positioning of volumes of gravity. The shape of the gravity field can be changed, enabling you to have a gravity field around an object, or only in a part of your scene. By making gravity objects children of your real objects you can have them move and rotate as your objects do.


The forces may be set to deteriorate over distance, this behavior is called falloff.

The type of falloff can make a big difference to your collisions. For some collisions having no falloff can mean you need a higher accuracy to simulate the physics. If you have a lower accuracy, then should an object get too far into a gravity field before the calculations are affected by it, the object can be given too much of a push and will gain more energy than before it collided; if this continues, eventually your simulation will have objects moving so fast that they vanish from sight.

A way to control this is to use only a thin shell of gravity around objects, and this is set with the falloff. By using the inverse square falloff you can soften collisions and help prevent sudden explosions of energy. The inverse square falloff gives the objects a push away as they get close, and then only as they get very close do they collide.

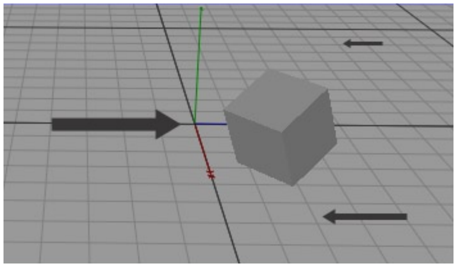

The centre of mass is used to determine if an object is inside another's field of influence.

A good point to remember is that all of this takes place at the centre of mass. You need to have the gravity field size large enough so that the distance between objects' centres of mass doesn't enable the geometry to penetrate too far into each other. It is also useful to remember that you can move the centre of mass of objects; in some cases you can move this to enable easier control over the collisions, or to prevent some objects from interacting with the gravity.

Drag

In the real world objects tend to interact in such a way that energy is transferred away from their motion. Unless you are in outer space, any movement is resisted by the air and surfaces around you.

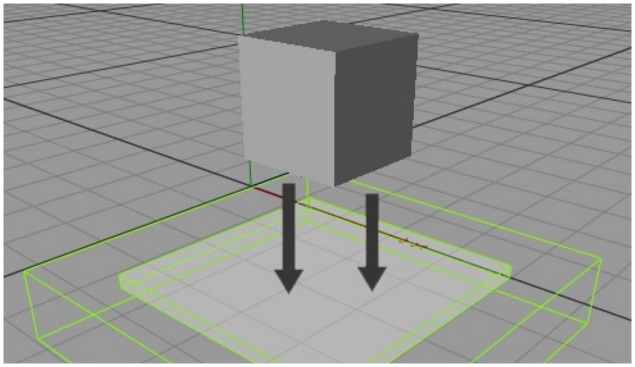
Drag is able to simulate air resistance, water, slime or even very dense substances such as mud.



To create this type of slowed motion you can add a Drag object. By using drag you can create an environment around objects that is similar to air. By using a low strength drag you can help the solver by continually lowering the speeds of the objects, helping to prevent them from gaining more energy than they started with. This is a useful point to remember: energy always appears to be lost — if you drop a ball on to the floor, it will never bounce higher than the point from which you dropped it, and eventually it will stop bouncing altogether.

You can also use the energy loss option in the Solver object. This is an important value to get to know; by using this you can control the object's movement and reduce any errors that can occur. By balancing the integration method and the oversampling used in the solver with the energy loss you can usually lower the oversampling, greatly speeding up the calculations. In many scenes it may be possible to replace drag with the energy loss, but remember that the energy loss will apply to all objects in the solver.

If we find that our simulation is not running smoothly, drag can often be used to calm everything down.



Drag objects have other uses, apart from giving an environment of air or fluid type resistance. By using volumes of drag you can carefully position them around your scene to help change the motion of objects.

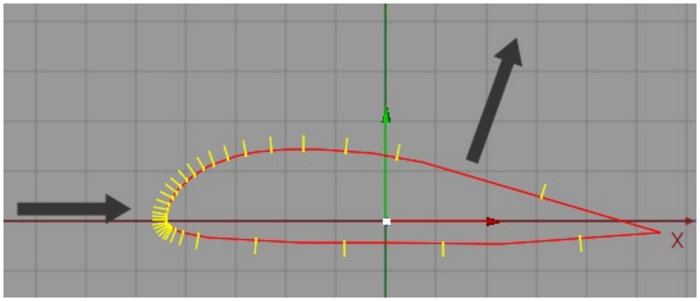
By using anti-drag (negative drag strength) you can increase the velocity or rotation or your objects. If you want to do this, remember that the object must already have some values; try starting the object off with a very small velocity and very small angular velocity. However, keep in mind that drag cannot change the direction of the motion, only speed it up or slow it down.

Drag is useful to prevent or stop jitter or motion. If you use a gravity collision (see above), objects may jitter if they continually collide. An example would be a ball falling on to a floor — careful positioning of a Drag object in a cube shape can stop the object from moving and colliding, giving the impression of it coming to rest on the floor.

Drag may also be used to prevent objects from penetrating gravity fields too much during collisions. The discrete nature of the motion means that an object could enter a gravity field too far. The first repulsion would move the object to the edge of the gravity, but still within it, so then on the next frame it gets repulsed again, giving the object far too much energy, which can lead to the scene exploding from view. If you position a drag within your gravity, then any objects entering too far will also be affected by the drag and the effects of the gravity are greatly reduced, helping to stop sudden explosions of speed during collisions.

Wind

So far in this outline of dynamics, the forces have all been straightforward, acting only on the centre of mass of each object or the point masses of the soft bodies. The Wind object is slightly more complex in that the actual polygons and their associated normals are used to find the overall force.



Wind offers many real-world options such as lift and drag, as well as the more basic ones such as impact.

This force can be used to give the impression of wind acting on an object to blow or lift it. As with gravity, the wind force can alter the path of an object, and as with the other forces, the centre of mass (or the origin for a soft body) must be within the bounds of any shape used for the wind. By varying the strength of the wind and its direction (by using keyframes and adjusting the parameters) you can add effects such as turbulence and gentle breezes.

Most of the time real world wind will fluctuate rather than give a constant force, so you may find a small amount of keyframing of the wind useful to give that extra realistic touch.

Collisions

The most noticeable change in an object's motion tends to be during collisions with other objects. Dynamics offers full collision detection so that you can have your scene fully interacting in a realistic way.

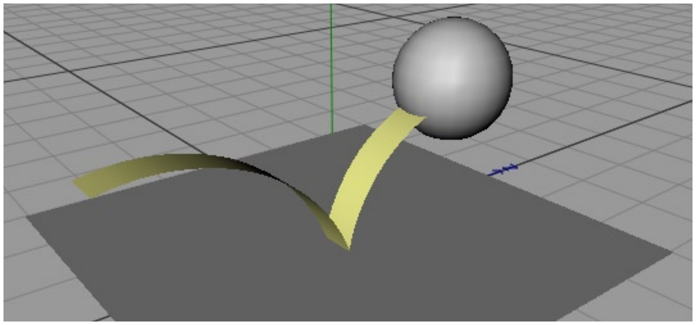
Although collision detection may be desirable, using it is even more computationally expensive than the motion calculations. Imagine you had a scene filled with many objects, and each object has many polygons. Taking a simplified example of collision detection where any polygon can collide with any other polygon, each must be checked and the appropriate motion calculated. Naturally, the collision detection in Dynamics is not this simple and performs many complex tests to help speed up the detection, but still the checks and calculations are numerous and lengthy, making collision detection a slow process, so it needs to be used cautiously.

A reasonable solution is to use full collision detection only when absolutely necessary, and to use the simplest geometry as possible (your real object can be a child of the simplified geometry).

Or use one of the simpler collision detection types available. If the collisions are not fully visible or can be carefully controlled, then you can use the forces as another collision detection technique that gives a much faster solution. Our 'Gravity Collisions' tutorial illustrates this technique using gravity.

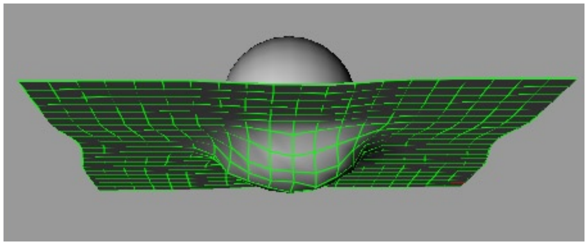
In the real world all solid objects will collide if they try to move into the same places. Collisions give rise to complex motion where an object might rotate, slow down, speed up, change its path.

Collision detection is another of Dynamics' powerful features.



When objects come into contact they also experience frictional forces as the surfaces push and grind against each other. Dynamics has an advanced collision detection system that can aid in simulating this friction.

Soft bodies will also interact with collisions, and also may have collision detection with themselves to prevent the geometry from penetrating itself, which cannot happen in the real world. As with rigid bodies, the collisions are time consuming, and if an alternative method can be used then it may be advisable to do so.


It is possible to create collisions between soft bodies and rigid bodies.

Although using realistic collisions can be essential for close-up shots during an animation, they do have some drawbacks that should be considered during planning.

Limitations

The main limitation of the full collision detection is the sheer amount of computing needed to check and calculate the complex motion. This processing can be reduced by using simple geometry which has only the main surface features and then using the real object as a child.

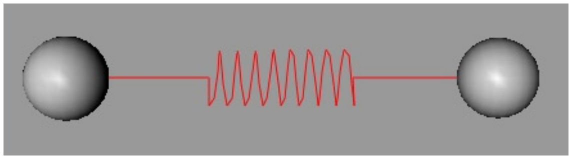
To enable faster collision detection, Dynamics provides some simple geometry types for the collision tests. If you can make your geometry even simpler than these built in ones, then you may find using the parent (simple) and child (real) method faster than using the built-in simple geometries.

When the collisions are controlled or not a main part of your scene, you may be able to use the simpler force collisions that were outlined above in Gravity and Drag. These have the great advantage of speed, but also require a little more time to correctly set up the objects, plus they may need more adjustments should you later alter the scene. The advantage real collisions have is that they will always interact in a realistic way.

Springs

By adding a spring between two objects you can give them a simple form of constraint. This join can be made to act as a usual spring would, so that if you compress it the spring resists and gives a force pushing the spring back to its original length (the 'rest' length), and if you try and stretch the spring it will pull back with a force again to its rest length. By increasing the stiffness you can create a simple link that can hold two objects together.

Many objects are not linked by solid geometry such as hinges or joints. In these cases, use springs.



As with the soft body springs you can use the plastic property of springs so that if they become stretched or compressed by a certain amount they will permanently deform. You also have the option to break the joint if the stretching or compression becomes too great.

Springs also have the ability to rotate an object; this 'angular' type of spring behaves as a coiled spring would in an old-fashioned wind-up clock.

Constraints

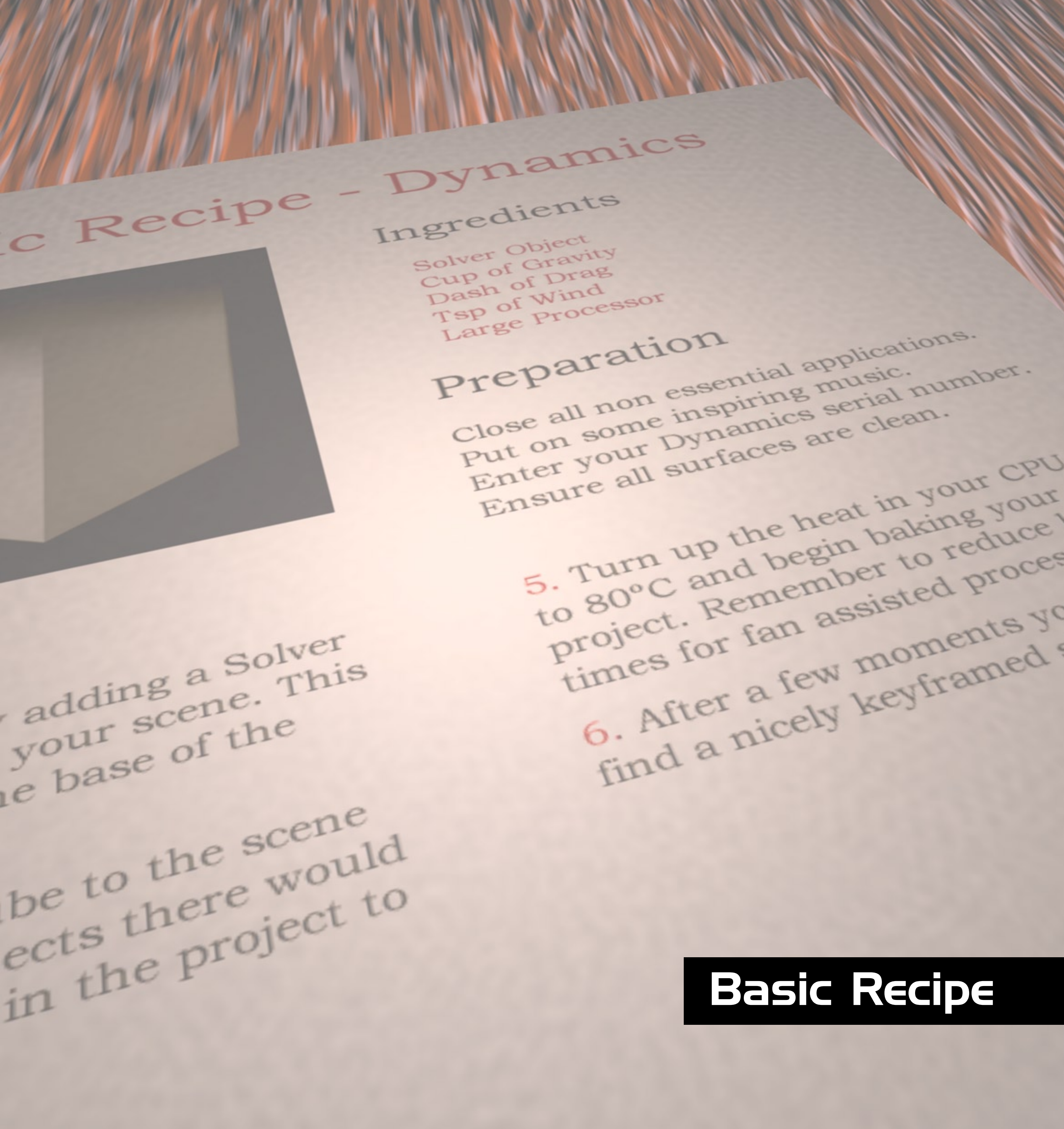
The forces we have so far seen in Dynamics make up much of our real world experiences. There is one more macroscopic force that we all experience from time to time; this is known as electromagnetism.

Electromagnetism shows up all over our lives, from magnets on fridge doors to the electricity that powers your computer. This force is also what binds and holds all objects together and forms the very links and bonds that make our world. When two objects collide, it is this electromagnetic force that stops them from penetrating each other.

Although Dynamics does not have this electromagnetic force, it does enable you to simulate these types of collisions.

In the real world we create joints and pins to stop objects moving, or to control how they are allowed to move, by causing collisions. Achieving this with the collision detection in Dynamics is possible, but will be very complex and can be very slow in calculating all the complex collisions that may have to happen in order to stop a simple interaction. To enable a fast and efficient solution to this, Dynamics has a Constraint tag that can restrain the motion of objects, thus providing the links that occur naturally between objects.

This ability enables you to limit the movement that the dynamics can exert on the objects under simulation. Constraints can be used to link objects together, fix an object to a point or to an axis so that it can slide along the axis, or to fix movement so that objects can not be slowed down or speeded up by the forces in the scene — just as an engine would push an object along at a constant speed even though air resistance and friction try and stop it.



c Recipe - Dynamics

Ingredients

Solver Object
Cup of Gravity
Dash of Drag
Tsp of Wind
Large Processor

Preparation

Close all non essential applications.
Put on some inspiring music.
Enter your Dynamics serial number.
Ensure all surfaces are clean.

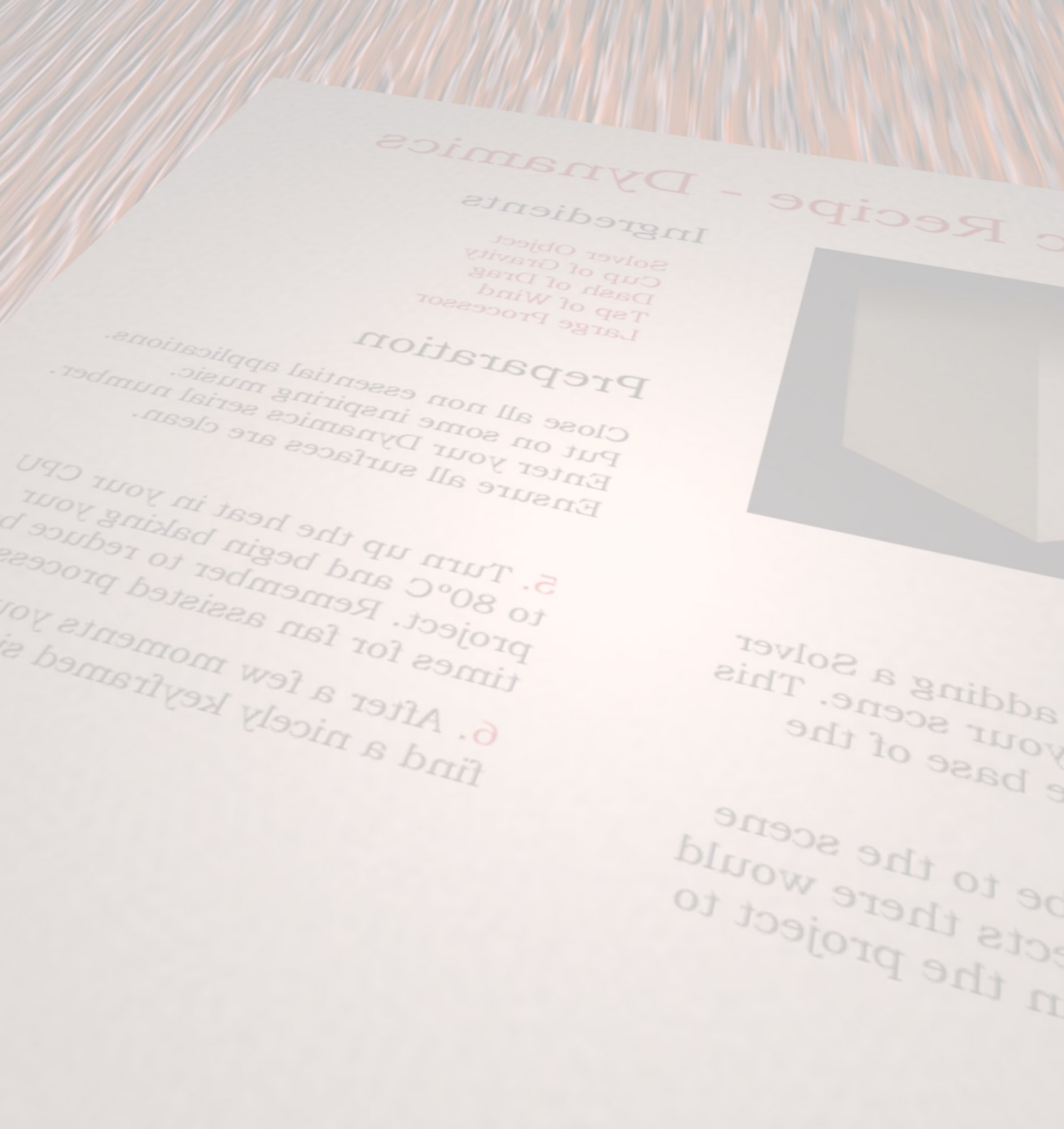
adding a Solver
your scene. This
e base of the

be to the scene
ects there would
in the project to

5. Turn up the heat in your CPU
to 80°C and begin baking your
project. Remember to reduce
times for fan assisted proces

6. After a few moments yo
find a nicely keyframed s

Basic Recipe



c Recipe - Dynamics

Ingredients

Solver Object
Cup of Gravity
Dash of Drag
Tsp of Wind
Large Processor

Preparation

Close all non essential applications.
Put on some inspiring music.
Enter your Dynamics serial number.
Ensure all surfaces are clean.

5. Turn up the heat in your CPU
to 80°C and begin baking your
project. Remember to reduce b
times for fan assisted process

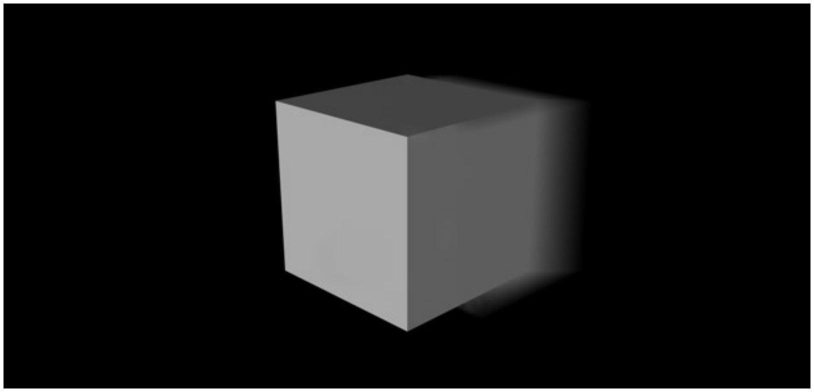
6. After a few moments you
find a nicely keyframed si

adding a Solver
your scene. This
e base of the

e to the scene
cts there would
n the project to

Basic Recipe

In this tutorial we'll take some simple basic first steps that ensure a working Dynamics simulation. We'll also highlight some things you should watch out for.



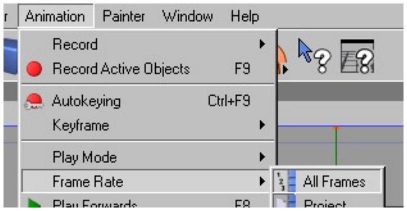
To begin any dynamics within CINEMA 4D we need to add some additional objects and tags into our scene. The Solver object is where all the magic happens, and this is the main control over how the dynamics engine works, how accurate and thus how fast the dynamics can be calculated.

We'll learn how to create a solid (rigid) object and give it a mass to which a velocity can be applied. We'll learn how to set an object in motion, how to add gravity so that the moving object also falls, and how to add some drag or 'air resistance' to further enhance the realism of the movement.

Lastly we will learn a simple way to stop a moving object when it 'hits' a solid, unmovable object like a floor.

▶ **Ensure that Animation > Frame Rate > All Frames is enabled.**

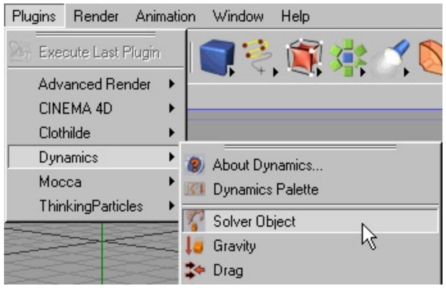
We must display all frames to ensure that we do not miss any unusual movements.



When using dynamics we need to be able to see every frame; this enables us to check that every frame is how we want it to look, plus it prevents the dynamics from calculating many frames at once, which can be slow on some complex scenes.

▶ **Select Plugins > Dynamics > Solver Object.**

We need at least one Solver object in our project to turn on Dynamics.



A Solver object will appear in the Object manager; this object is where we will add the objects that we want to interact through dynamics.

▶ **Click on the Solver object's icon, set the Integration Method to Midpoint and the Oversampling to 4.**

By using a Midpoint method, the dynamics system can be calculated very quickly. Although it is not the most accurate method, it will make almost no difference to this scene. To make it slightly more accurate, an Oversampling setting of 4 will calculate four imaginary frames between each real frame.

▶ **Set the Energy Loss to 0.**

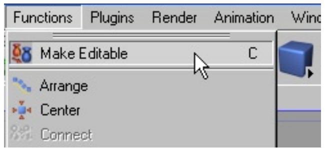
Using the default Energy Loss of 5% can often be beneficial, however in this case it would cause out objects to slow down far too quickly.

▶ **Select Objects > Primitive > Cube.**

We'll begin by making a simple cube move using dynamics.

▶ **Ensure you have the Cube object selected, then select Functions > Make Editable and drag the Cube object into the Solver object.**

Only polygon objects can make use of Rigid Body Dynamic tags.

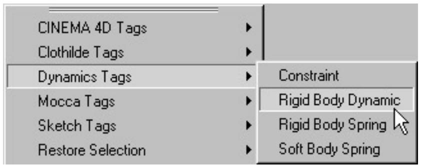


To perform dynamics on an object we must have it within the solver and it must be a polygon object (Make Editable ensures this).

Command-click on a Mac if you have only one mouse button.

▶ **Making sure you have the Cube object selected, right-click and select Dynamics Tags > Rigid Body Dynamic.**

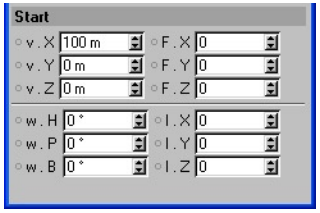
By default, the Rigid Body Dynamic tag will give our cube a mass.



This will add a new tag to the Cube object, and the tag's settings will appear in the Attribute manager. For us to move the cube, we want it to become a solid object and to have a mass so that we can tell the dynamics what velocity the cube should start moving with.

▶ **Click on the Start tab and set the v.X value to 100.**

Objects can be given an initial speed and rotation from the Start tab.



Start

v.X	100 m	F.X	0
v.Y	0 m	F.Y	0
v.Z	0 m	F.Z	0
w.H	0 °	I.X	0
w.P	0 °	I.Y	0
w.B	0 °	I.Z	0

By setting the v.X parameter we tell the dynamics to move the cube along the positive x-axis by 100 units per second. Close the window when you're finished.

▶ **Click Play and then click stop when you are finished.**

We now need to view the dynamics animation to check all is working as we intended. As you can see, the Cube object moves slowly down the x-axis.

▶ **Select Plugins > Dynamics > Gravity and drag the new Gravity object into the Solver object.**

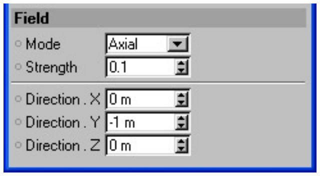
This adds some world gravity to make the object fall as it moves.

▶ **Click Play and then click Stop when you are finished.**

The cube now falls as it moves along the x-axis.

▶ **Click the Gravity object's icon and set its Strength to 0.1.**

The default gravity strength of 1 may be too much for our scene so we have reduced its strength.



Field

Mode	Axial
Strength	0.1
Direction . X	0 m
Direction . Y	-1 m
Direction . Z	0 m

This will slow down the fall of the cube due to gravity so that we can see the curve of the object's movement as it falls and moves along the x-axis.

▶ **Click Play and then click Stop when you are finished.**

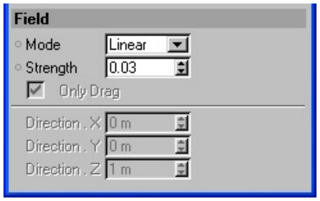
As you can see, the cube falls once more, but this time it takes longer to fall because we lowered the gravity strength.

▶ **Select Plugins > Dynamics > Drag and drag the Drag object into the Solver object. Change the name of the Drag object to Air.**

We've just added some air resistance to the scene, this makes it a little more realistic. An alternative would have been to leave a small amount of Energy Loss in the Solver settings.

▶ **Click on the Air object's icon and set its Strength to 0.03.**

Air resistance will be encountered in almost all everyday locations; this, too, can be simulated.



Field

Mode	Linear
Strength	0.03
✓ Only Drag	
Direction . X	0 m
Direction . Y	0 m
Direction . Z	1 m

We want to slow the object very slightly as it moves, so setting low drag strength will slowly resist the object's movement.

▶ **Click Play and then click Stop when you are finished.**

The cube now begins moving and then gradually stops moving along the x-axis and just falls. Gravity is accelerating the cube downwards on every frame so the drag makes little difference, but the velocity at the start has no force keeping it moving and so slowly the drag stops this motion.

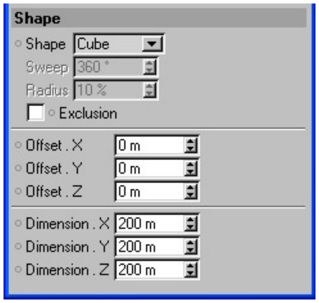
▶ **Select Plugins > Dynamics > Drag but this time do not drag the Drag object into the solver. Change the name of the Drag object to Floor.**

We're now going to add a soft floor for the cube to fall on to. This is a way to stop the object from falling further, and a soft floor will have little or no bounce, so we can use a drag object to stop the cube moving as if it had hit the floor.

▶ **Click the Floor object's icon and set its Strength to 10.**

▶ **Click the Shape tab and select the Cube Shape.**

Collisions do not have to be between solid objects. There is no reason not to use a very strong gravity or drag field to halt something.



Shape

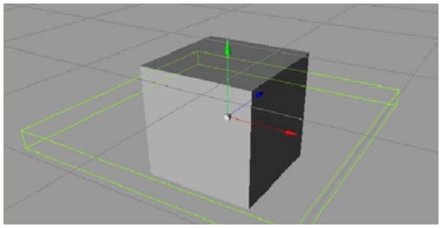
Shape	Cube
Sweep	360 °
Radius	10 %
Exclusion	☐
Offset . X	0 m
Offset . Y	0 m
Offset . Z	0 m
Dimension . X	200 m
Dimension . Y	200 m
Dimension . Z	200 m

We want to create a local volume of drag that can act as a floor. It is important to remember that as with other force objects in Dynamics, only the centre of mass is used for the interaction; this means that we must ensure that any real geometry placed in the scene will react before the geometry intersects. So with our cube, if we had a real floor object we would need to place it far enough into the drag cube so that the cube's bottom surface stops before the cube goes through the floor.

▶ **Click Play. When the cube is in the position where the floor drag should stop it, click Stop.**

We need to find out where the cube will be when it should hit the floor. This will make placing the Floor object much easier.

▶ **Move the Floor object so that its centre is in the same position as the cube's centre. Scale the Floor object along the y-axis (by changing the Dimension.Y in the Attribute manager) to make a floor.**


Position and scale the drag field to create a floor-like object.

This will be where the cube comes to a stop as it hits the floor. By increasing the strength of the drag we can stop movement almost immediately.

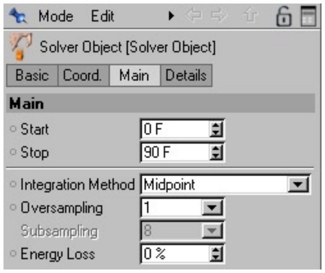
► **Drag the Floor object into the solver.**

► **Click Go to Start of Animation and then click Play; click Stop when you are finished.**

As you can see, the cube falls as before, and then stops as the centre of mass comes into the floor drag.

► **Click the Solver object's icon and set the Oversampling to 1.**

Although lower solver settings equate to fewer calculations, they can be inaccurate and lead to problems.



Start: 0 F
Stop: 90 F
Integration Method: Midpoint
Oversampling: 1
Subsampling: 8
Energy Loss: 0 %

► **Click Play and then click Stop when you are finished.**

This time you can see the cube shoots away from or through the drag. The reason why is that we made the dynamics less accurate. The large value set for the drag strength causes the solver to explode and the motion of the cube to be calculated incorrectly. This is an important point to remember. If you find your motion is going wrong, check your solver settings; you may find increasing the accuracy or method helps, or you may have to reduce the values used in your objects.

Summary

We have seen how to add the Solver object that controls the dynamics simulation, how to add in your objects and then how to make them interact with dynamics objects within the simulator and to be controlled by the dynamics itself.

With the simple example of a falling cube we've also seen how to use drag to perform a simple collision with a soft floor and to give the impression of a cube landing.

We have also seen how we can adjust the Solver object to correct for any unpredictable motion and how this can relate to the values used in the dynamics objects.

Once we understand these basic principles we will be able to begin experimenting with Dynamics and create our own dynamic animations from scratch.

Move and Stop

Move and Stop

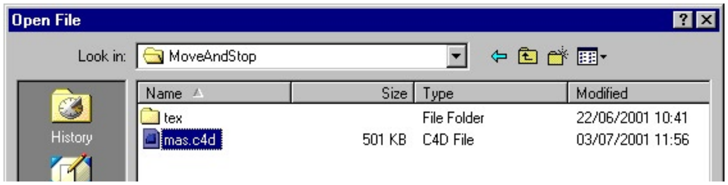
In this tutorial we will learn how to set an object in motion, alter its trajectory and then stop it at a predetermined point. Quiet please, game on...

This tutorial demonstrates how to create a simple dynamics simulation of a dart in flight that strikes a dart board. The simulation makes use of rigid body dynamics, illustrating the initial setting up of a rigid body, plus it uses force fields to simulate a collision between dart and board.

Though Dynamics features collision detection, it's not always prudent to use it. In this case using force fields also offers us more control.

▸ **Select File > Open. Navigate to the Move And Stop tutorial folder on your Documentation CD and open the file named 'mas.c4d'.**

Open the file to begin the tutorial.
The Tutorials folder is in the Dynamics module folder. Each tutorial has its own folder within the main Tutorials folder.



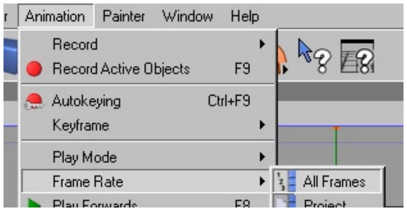
Look in: MoveAndStop

Name	Size	Type	Modified
tex		File Folder	22/06/2001 10:41
mas.c4d	501 KB	C4D File	03/07/2001 11:56

This is the initial, non-animated darts scene. We are going to create a dynamics simulation to score a treble 20 with our dart.

► **Ensure that Animation > Frame Rate > All Frames is enabled.**

When working with Dynamics, always enable the All Frames option to ensure a smooth workflow.



When using dynamics we need to be able to see every frame; this enables us to check that every frame is how we want it to look, plus it prevents the dynamics from calculating many frames at once, which can be slow on some complex scenes. When working with dynamics we should make it a habit to ensure that All Frames is enabled.

► **Select Plugins > Dynamics > Solver Object.**

All dynamics animations need to be set up using special objects that control how the dynamics system will run. The most important object is the dynamics solver, which actually does all the calculation.

► **Click the Solver object's icon and set the Integration Method to Adaptive and the Stop frame to 19.**

The dart will fly for only a very short period of time, and at a very high velocity. Choosing the Adaptive method enables us to sub-sample the frames further when necessary. We have chosen to stop the simulation at frame 19 because by then the dart will have come to a full stop. If the solver continued to calculate the frames it would slow things down unnecessarily.

► **Set Oversampling to 16, Subsampling to 128.**

Each frame will be divided into a further 16 virtual frames. During each of these frames, Dynamics will check to see if the dart has reached the board. When the dart nears the board, sub-sampling will begin and each of the 16 virtual frames will be divided again into another 128 frames.

► **Set the Energy Loss to 0.**

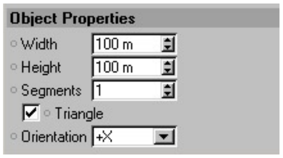
There is no need for the system to artificially lose energy. All of the motion energy will be dissipated by the drag fields (which have yet to be added).

▸ **Select Objects > Primitive > Polygon.**

If you unfold the Dart hierarchy you can see it is made from lots of separate objects. However we really only need to apply the dynamics properties to one object. We could connect the Dart hierarchy to form a single object but then it would lose its texturing. A better option is to add a special helper object set so it doesn't render in the final animation and use this as a container for the Dart object. That's what we are doing here.

▸ **Click on the polygon's icon, set the Orientation to +X and enable the Triangle option.**

All rigid Dynamics objects must be polygons; use a simple invisible one and attach the real objects to it.



Object Properties
Width 100 m
Height 100 m
Segments 1
[✓] Triangle
Orientation +X

This creates a triangle polygon which we can animate as if it were the dart object.

▸ **Press the 'c' key.**

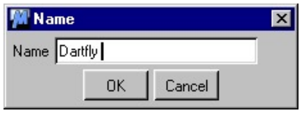
This will turn the primitive into an editable polygon object, as required by Dynamics. (The 'c' key is the keyboard short-cut for the Functions > Make Editable command.) The exact shape and size of this object is actually irrelevant, though if the rendered object is very complex, to speed display we can preview the simulation using this container only.

▸ **In the Object manager, drag the Dart object into the Polygon object.**

When we animate the Polygon object, the dart will move too, just like any other hierarchy in CINEMA 4D. Remember that dynamics only works with polygon objects, which is why we used a Polygon object for the container and converted it. Empty polygons, splines or nulls will not work.

▸ **Double-click on the Polygon object's name and rename it Dartfly.**

Naming objects as we go along is always a good idea.



Name
Name Dartfly

Because both the Dart and the Dartfly objects are at the origin we don't need to adjust their relative positions.

▶ **Drag the Dartfly object into the solver.**

If you play the animation now nothing will happen because we have not added any forces or dynamic properties to the system — the solver has nothing to solve, so this is the next step.

▶ **Select Plugins > Dynamics > Gravity.**

Gravity is required to make the dart fly in a slight arc rather than perfectly straight.

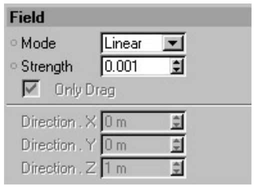
▶ **Select Plugins > Dynamics > Drag.**

It's a good idea to always add a Drag object to our simulations to provide a kind of all-round damping for the solver, and to prevent the system from spontaneously gaining energy. Our Drag object is going to slow down the dart while it is in flight, simulating air resistance.

▶ **Drag the Gravity and Drag objects into the solver.**

▶ **Click the Drag icon and on the Field tab set the Strength to 0.001.**

Depending on the scale of our scenes, the default drag strength may be more akin to water.


Field
Mode: Linear
Strength: 0.001
☑ Only Drag
Direction . X: 0 m
Direction . Y: 0 m
Direction . Z: 1 m

The default value is too high and is more like water than air. By reducing the Strength we are thinning the drag.

▶ **In the Object manager, select the DartFly object, then select File > Dynamics Tags > Rigid Body Dynamic.**

We need to assign a special Rigid Body Dynamic tag to the Dartfly object. This provides the object with various dynamic properties that we can change to create our customised simulation. This, together with the gravity and drag force fields, defines the dynamics system and provides the solver with enough information to create a simulation.

▶ **Click Play and click Stop when you are finished.**

Now if you play the animation the dart will begin to drop. Remember it's the polygonless Dartfly object that is being animated by the dynamics, the real Dart object is merely going along for the ride.

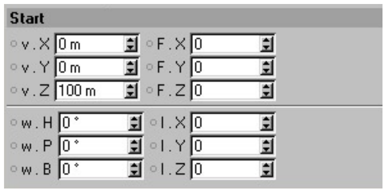
► **Click on the Dartfly object's Rigid Body Dynamic tag.**

In order to propel the dart into the dartboard we must give it some energy. We can do that by adjusting the Rigid Body parameters.

► **In the Attribute manager, click the Start tab.**

This is where we define the initial trajectory of the rigid body object.

► **Set the v.Z value to 100.**



Start

v.X	0 m	F.X	0
v.Y	0 m	F.Y	0
v.Z	100 m	F.Z	0
w.H	0 °	I.X	0
w.P	0 °	I.Y	0
w.B	0 °	I.Z	0

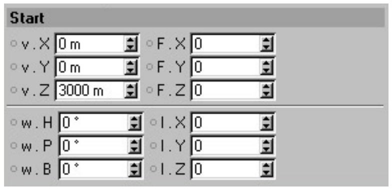
We need to give our dart a little push to set it moving.

The first section at the top left, the 'v.' values, tells Dynamics how fast the object is moving initially in each direction. Note that these values are only for the start of the simulation, it's like giving our object an initial push to get it going.

► **Click Play and click Stop when you are finished.**

Playing the animation, we can see that the dart moves forward slightly as it falls under the pull of gravity. It seems that a value of 100 is not nearly enough to get it to the dart board.

► **In the Rigid Body Dynamic tag's settings, set v.Z to 3000.**



Start

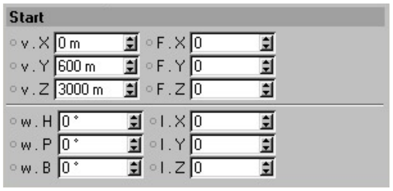
v.X	0 m	F.X	0
v.Y	0 m	F.Y	0
v.Z	3000 m	F.Z	0
w.H	0 °	I.X	0
w.P	0 °	I.Y	0
w.B	0 °	I.Z	0

At a speed of 3,000 the dart flies quickly.

A value of 3000 should provide just the right amount of oomph, and at around frame 16 the dart should intersect the board.

▶ **Set v.Y to 600.**

A bit of upwards thrust will create an arced flight.



v.X	0 m	F.X	0
v.Y	600 m	F.Y	0
v.Z	3000 m	F.Z	0
w.H	0 °	I.X	0
w.P	0 °	I.Y	0
w.B	0 °	I.Z	0

If we were throwing a dart at a dartboard we would instinctively make some compensations for the effect of gravity and project the dart in an upwards arc rather than desperately trying to throw it in a straight line at our target. In order to improve our score, we need to adjust the flight of the dart by giving it a little upwards (Y) energy.

▶ **Click Play, click Stop and rewind when you are finished.**

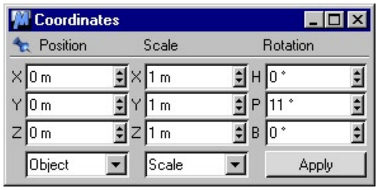
The dart now flies in an arc and intersects the board at the treble 20 mark.

▶ **Disable the Solver object by clicking on its green tick icon in the Object manager.**

If you try to rotate the Dartfly object while the solver is still enabled, you will find it is totally unresponsive and it will not remember any settings you change. Before changing any dynamics objects you must first disable the solver.

▶ **Select the Dartfly object in the Object manager, then, using the Coordinate manager (or the Coordinates tab in the Attribute manager), rotate the Dartfly object's pitch to 11 degrees.**

We have the arced motion of the dart, now we need it to point in the direction it is moving.



Position		Scale		Rotation	
X	0 m	X	1 m	H	0 °
Y	0 m	Y	1 m	P	11 °
Z	0 m	Z	1 m	B	0 °

The flight of the dart still isn't right. Really the dart should follow the arc rather than remain pointing in the same direction. We can adjust its initial orientation then add a small amount of angular movement in the Rigid Body dialog to make the dart rotate in its flight. The setting we have just made is the angle at which the dart will be thrown.

▶ **Select Plugins > Dynamics > Initialize Object.**

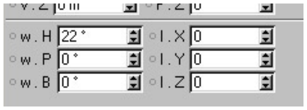
We must store this new position before re-enabling the solver, otherwise it will revert to its original position.

▶ **Enable the solver by clicking on its red X icon in the Object manager.**

For dynamics to have any effect on the scene, the solver must be enabled, otherwise nothing will move or rotate when we play the animation.

▶ **Click on the Dartfly object's Rigid Body Dynamic tag. Click the Start tab and set the w.H value to 22.**

Some tweaking of the parameters is needed.


w . H 22 °
w . P 0 °
w . B 0 °
I . X 0
I . Y 0
I . Z 0

▶ **Click Play and click Stop when you are finished.**

Now when the simulation plays the dart will rotate in flight so that it intersects the dartboard at a nearly perpendicular angle.

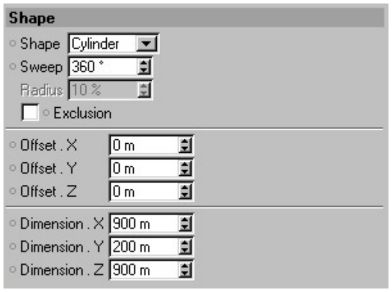
▶ **Select Plugins > Dynamics > Drag and drag this new Drag object into the solver. Rename it BoardDrag (by double clicking on its name).**

All well and good so far but the dart is passing right through the board and the wall. We need to stop the dart so it sticks in the dartboard by just the right amount. Dynamics enables us do this using forces. There are two good reasons for using forces, firstly it is much more efficient than using collision detection, and secondly the dart needs to partially penetrate the board rather than bounce off it; forces gives us the control to be able to achieve this.

▶ **Click on the Board object icon then click the Shape tab and set Shape to Cylinder.**

▶ **Set Dimension.X to 900, Dimension.Y to 200 and Dimension.Z to 900.**

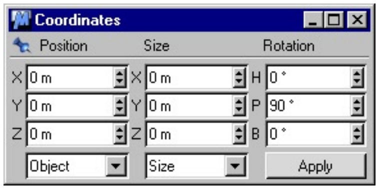
The drag field needs to be roughly the same shape as the dartboard geometry.


Shape
Shape Cylinder
Sweep 360 °
Radius 10 %
Exclusion
Offset . X 0 m
Offset . Y 0 m
Offset . Z 0 m
Dimension . X 900 m
Dimension . Y 200 m
Dimension . Z 900 m

We can make the drag field affect a specific region of space by giving it a limited area of influence. We have made it a cylinder as this is the shape of the dartboard.

► **Ensure the Board object is selected in the Object manager, then, using the Coordinate manager, rotate the Board object 90 degrees in pitch.**

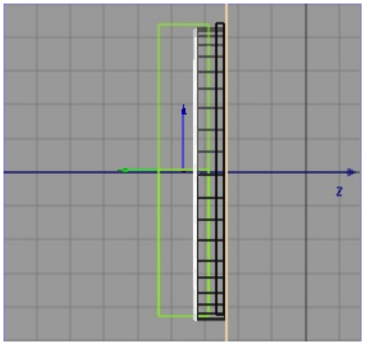
The drag field also needs to face in the same direction as the dartboard geometry.



	Position		Size		Rotation
X	0 m	X	0 m	H	0 °
Y	0 m	Y	0 m	P	90 °
Z	0 m	Z	0 m	B	0 °

► **Use the mouse in the viewports to move the Board object along its local Y axis until it is over the dartboard.**

The drag field needs to be in the same position as the dartboard geometry.



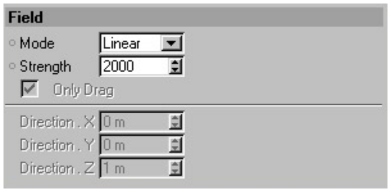
These last four actions above will position and scale the drag field over the real dartboard so that the darts appear to stop when they hit the board.

► **Click Play and click Stop when you are finished.**

If you play the simulation now you'll see that the dart is stopped by the dartboard but pokes through it!

► **Click on the Board object icon and on the Field tab set the Strength to 2000.**

The dart hits the board at a relatively high velocity, so the drag needs to be very strong to catch it.



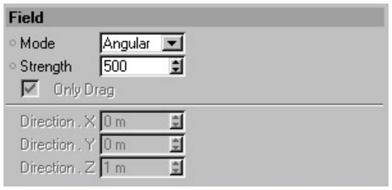
Mode: Linear
Strength: 2000
☑ Only Drag
Direction . X: 0 m
Direction . Y: 0 m
Direction . Z: 1 m

This will now cause the dart to actually stop when it encounters the dartboard rather than just slow down slightly. If the dart goes too far into the dartboard, move the Board object until the only the tip of the dart is stuck in the board. However, the angular momentum of the dart is causing it to rotate in the board even though it has stopped its flight.

► **In the Object manager, Ctrl-drag the BoardDrag object to duplicate it and then rename it BoardRot (by double clicking on its name).**

► **Click on the BoardRot object icon and on the Field tab set the Mode to Angular and the Strength to 500.**

A separate drag object is required to stop the dart rotating.

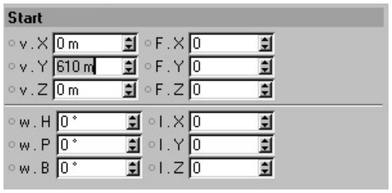

Field
Mode: Angular
Strength: 500
Only Drag: ✓
Direction . X: 0 m
Direction . Y: 0 m
Direction . Z: 1 m

We can stop the dart from rotating by using another drag field set to Angular mode. This will halt all unwanted rotations as the dart hits the board.

If you've used different values to the ones given in this tutorial you may find that the dart flies straight through the board! To solve this, increase the Oversampling and Subsampling values for the Solver object. This will increate the accuracy of the dynamics simulation.

► **Click on the Dart object's Rigid Body Dynamic tag. Click the Start tab and set v.Y to 610.**

One final adjustment is needed to get a respectable score ;-)


Start
v . X: 0 m | F . X: 0
v . Y: 610 m | F . Y: 0
v . Z: 0 m | F . Z: 0
w . H: 0 ° | I . X: 0
w . P: 0 ° | I . Y: 0
w . B: 0 ° | I . Z: 0

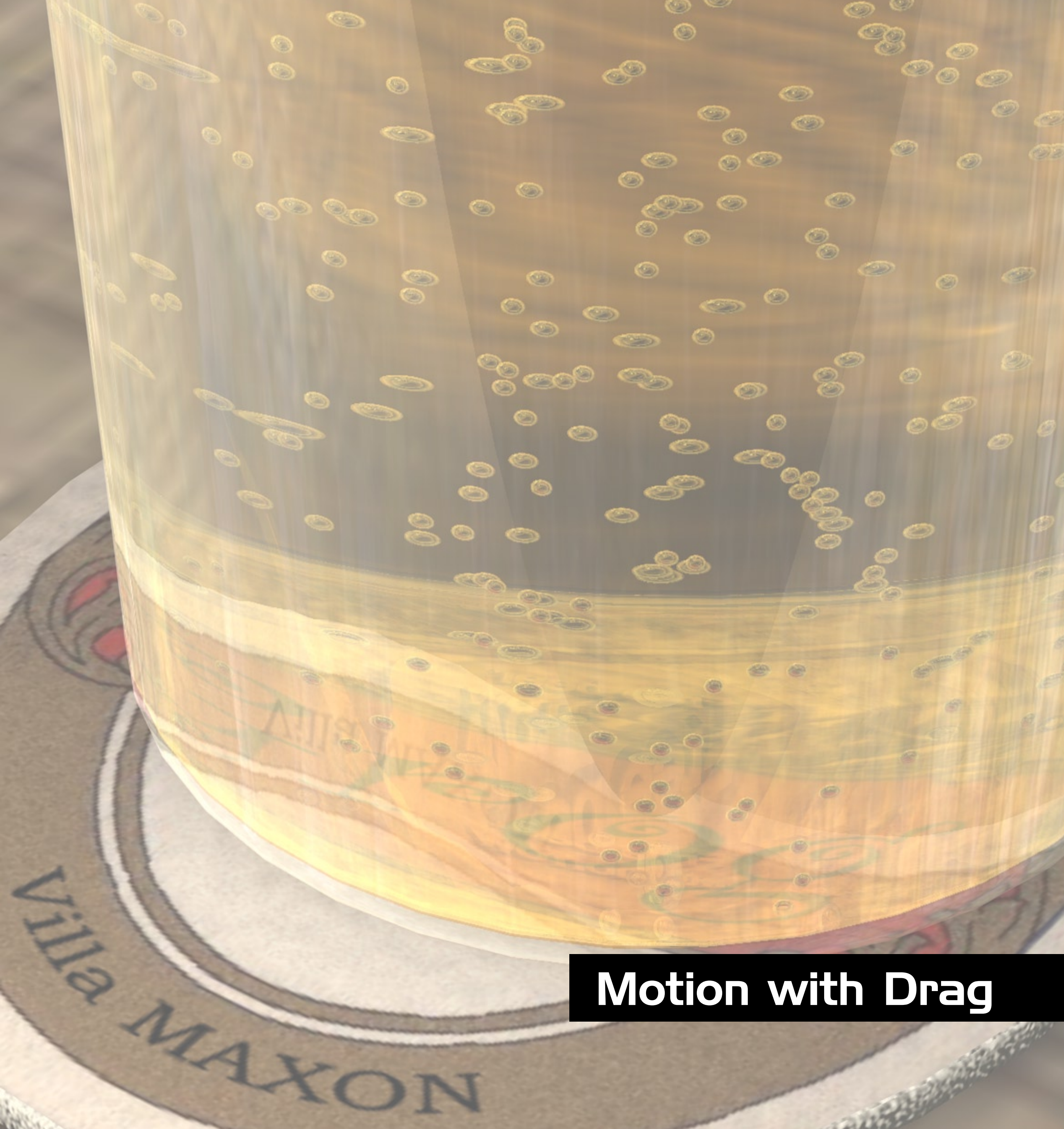
We can fine-tune the height at which the dart hits the board by adjusting the v.Y value. Time to practice our aim!

Summary

You should now understand how we can use a drag field to simulate the thickness of any object or substance, from flowing air and water right up to a wooden surface or sheet of steel. The strength of the drag all depends on how tightly packed the atoms are. To control the degree of penetration of the dart, simply move the BoardDrag drag field towards or away from the dartboard. To control how fast the dart decelerates within the field, scale it in Y and adjust the Strength.

You should also realise how much control we will be able to give our simulation; just because the dart stops when it hits the board does not mean that it has to stop rotating. It’s up to us!

If you're not sure how else you can use the objects we've just been using, take a look at the Newton's Cradle tutorial (Gravity Collisions with Constraints) where you will find more uses for both gravity fields and drag fields.



Motion with Drag

Motion with Drag

Creating a falling object that has its motion controlled by using drag objects to give the illusion of the object passing into a fluid.

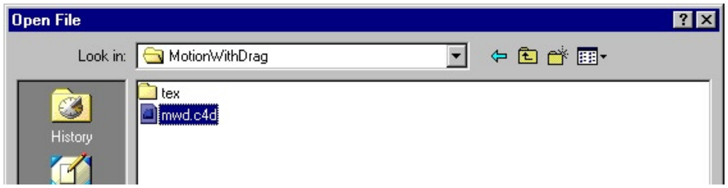
Free beer
...tomorrow

Altering the motion of our objects is essential to making a realistic looking animation. The Drag and Axial Gravity objects will be covered in this tutorial, illustrating how to use drag to speed up and slow down a moving and rotating object.

We will start by making a coin fall, followed by adjusting the fall to give the impression that the coin is falling into a liquid. This requires us to slow down the fall due to the viscosity of the liquid, then to cause the coin to tumble slightly before it finally comes to rest at the bottom of the glass.

► **Select File > Open. Navigate to the Motion With Drag tutorial folder on your documentation CD and open the file named 'mwd.c4d'.**

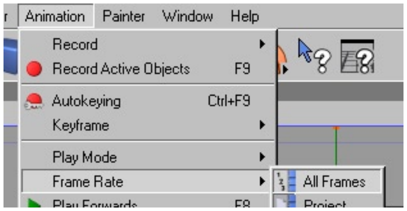
Open the file to begin the tutorial.
The Tutorials folder is in the Dynamics module folder. Each tutorial has its own folder within the main Tutorials folder.



The scene objects are now available in the Object manager. We now want to take our coin and drop it into the pint of beer. The two important objects in this scene are the Pint object and the Coin object.

▸ **Ensure that Animation > Frame Rate > All Frames is enabled.**

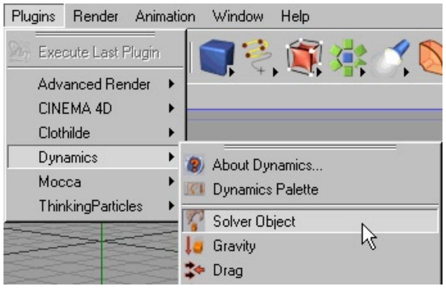
Display every frame to guarantee accurate calculations.



When using dynamics we need to be able to see every frame; this enables us to check that every frame is how we want it to look, plus it prevents the dynamics from calculating many frames at once, which can be slow on some complex scenes.

▸ **Select Plugins > Dynamics > Solver Object.**

Solver objects are needed for all Dynamics simulations.



A Solver object will appear in the Object manager; this object is where we will add the objects that we want to interact through dynamics.

▸ **In the Object manager, ensure you have the Solver object selected, then in the Attribute manager, click on the Main tab and set the Stop frame to 1000.**

We want the animation to last for the length of our timeline, so we set the stopping frame for the dynamics to the end frame on our timeline.

▸ **Leave the Integration Method set to Adaptive. Set the Oversampling to 4 and the Subsampling to 8.**

We are using the adaptive method because it produces very accurate results, which is always a good thing when we are working with complex scenes.

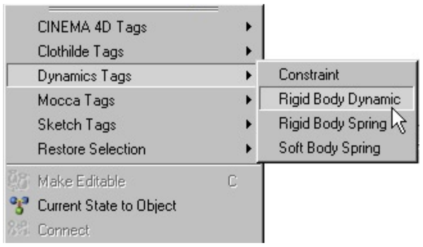
▸ **Set the Energy Loss to 0.**

There is no need for the system to artificially lose energy. All of the motion energy will be dissipated by the drag fields (which have yet to be added).

Command-click on a Mac if you have only one mouse button.

▶ **In the Object manager, ensure you have the Coin object selected, then right-click and select Dynamics Tags > Rigid Body Dynamic.**

To enable the coin to interact with other Dynamics objects we are giving it a Rigid Body Dynamic tag.



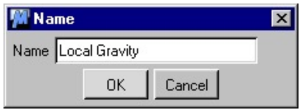
We need to make the coin a solid object so that we can use a Gravity object to make it fall into the beer; we will be using the Pint object as our beer in this scene.

▶ **Drag the Coin object into the solver.**

To enable the dynamics to take control of the coin falling we need it to be a child of the Solver object.

▶ **Select Plugins > Dynamics > Gravity. Double-click on the Gravity name in the Object manager and set the name to Local Gravity.**

If we rename our objects as we create them, we will save ourselves hassle when our projects become larger.



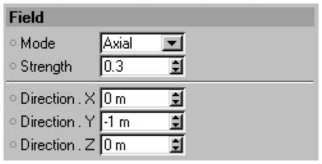
Name: Local Gravity

▶ **Drag the Local Gravity object into the solver.**

We need a Gravity object to give the coin the movement that will make it appear to fall; this will apply a force on to the centre of mass of the coin (set in the Rigid Body Dynamic tag).

▶ **In the Attribute manager, click on the Field tab and set the Strength to 0.3.**

In the Gravity dialog we can specify both how strong the pull is, and in which direction.

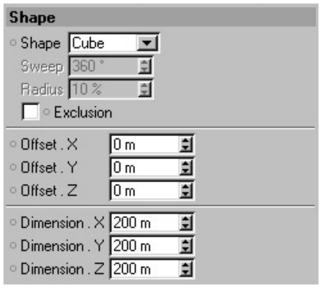


Field
Mode: Axial
Strength: 0.3
Direction . X: 0 m
Direction . Y: -1 m
Direction . Z: 0 m

We need the coin to accelerate only for a fixed amount, the remaining motion will be controlled by drag.

► **Click on the Shape tab and set the Shape to Cube.**

Gravity doesn't have to be everywhere, it can be restricted to a shape, in our case a cube.

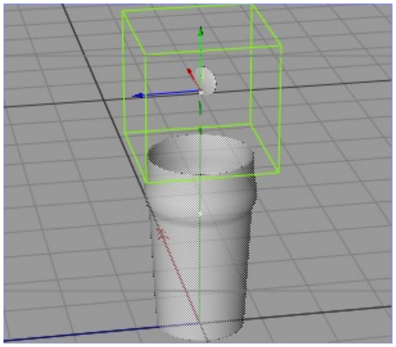

Shape

Shape	Cube
Sweep	360 °
Radius	10 %
☐ Exclusion	
Offset . X	0 m
Offset . Y	0 m
Offset . Z	0 m
Dimension . X	200 m
Dimension . Y	200 m
Dimension . Z	200 m

Here we need a only simple cube shape for the gravity so that we can control exactly where the coin is accelerated.

► **Select the Local Gravity object and move it up the Y axis so that the bottom of the gravity cube is just about at the top of the beer glass.**

Our cube of gravity needs to be positioned.



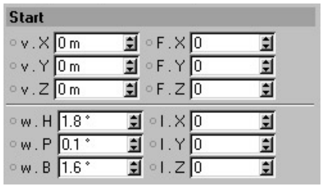
While the coin is in the air above the beer glass we want it to accelerate. Although normally we would also have air resistance, in this case we can ignore it because the coin falls only a short distance before it enters the fluid.

► **Click Play and then Click stop when you are finished.**

You can see that the coin begins to fall gently until it leaves the gravity cube, at which point in time it then moves at the same speed downwards. This gives us our starting point for the coin dropping into the beer.

▶ **Click the Rigid Body Dynamic tag for the coin object, then click the Start tab. Set w.H to 1.8, w.P to 0.1 and w.B to 1.6.**

All Dynamics objects can be given an initial motion; set it up on the Start tab.


Start

v . X	0 m	F . X	0
v . Y	0 m	F . Y	0
v . Z	0 m	F . Z	0
w . H	1.8 °	I . X	0
w . P	0.1 °	I . Y	0
w . B	1.6 °	I . Z	0

To use drag we need to have some velocity or angular velocity. Drag can only slow down or speed up our motion. We want to be able to spin the coin, so we need to give it a very small rotation so that it appears not to rotate until the time we want it to.

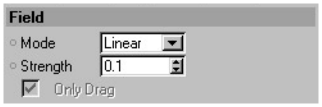
▶ **Select Plugins > Dynamics > Drag. Double-click on the Drag name in the Object manager and set the name to Enter Beer.**

▶ **Drag the Enter Beer object into the solver.**

We need to slow down the coin as it strikes the surface of the beer; this can be achieved with drag.

▶ **Click on the Enter Beer object's icon. In the Attribute manager, click on the Field tab and set the Strength to 0.1.**

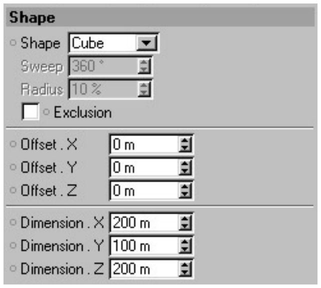
Reduce the strength of the drag so that the liquid becomes easier to pass through.


Field

Mode	Linear
Strength	0.1
✓ Only Drag	

▶ **Click on the Shape tab and set Shape to Cube and Dimension.Y to 100.**

The beer is present only inside the glass, so its area of influence needs to be restricted.

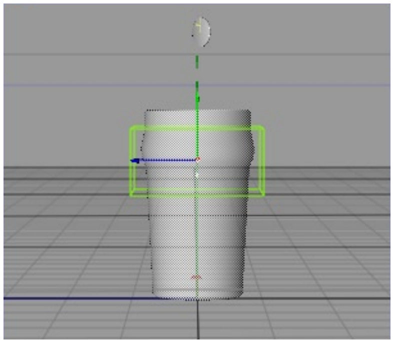

Shape

Shape	Cube
Sweep	360 °
Radius	10 %
☐ Exclusion	
Offset . X	0 m
Offset . Y	0 m
Offset . Z	0 m
Dimension . X	200 m
Dimension . Y	100 m
Dimension . Z	200 m

We only need to slow down the motion slightly at the very top of the beer, this needs to last only a short time so we use a flattened cube along the Y.

▶ **In the Object manager, ensure you have the Enter Beer object selected and move the cube up the Y axis so that the top of the drag cube is just below the surface of the beer.**

Now that the drag has been restricted to a certain area, it needs to be positioned inside the beer.



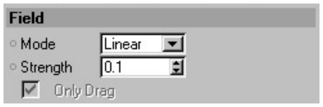
This small volume of drag will give us the slowing down we need to make it appear that the coin is entering a fluid. For this tutorial we'll simplify the motion and exaggerate the movement slightly to make it easier to follow.

▶ **Select Plugins > Dynamics > Drag. Double-click on the Drag name in the Object manager and set the name to In Beer, then drag In Beer into the solver.**

We need to gently slow down the coin as it passes through the fluid. In air the falling object would reach a maximum velocity known as the terminal velocity, but due to the short distance the coin is falling we will not need to concern ourselves with it.

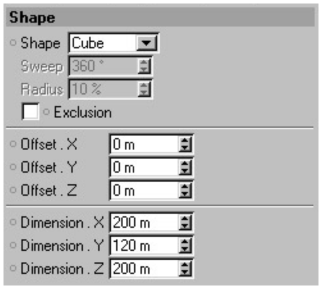
▶ **Click on the In Beer object's icon. In the Attribute manager, click the Field tab and set the Strength to 0.1.**

Just like the other two drag objects, this one will need to be cut down in size.


Field
Mode: Linear
Strength: 0.1
☑ Only Drag

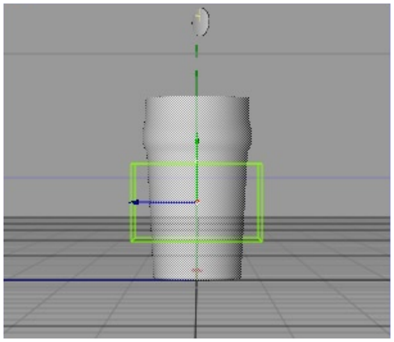
▶ **Click the Shape tab and set Shape to Cube and Dimension.Y to 120.**

Changing the drag object's shape means that it is no longer present everywhere, in our case only inside the green cube.


Shape
Shape: Cube
Sweep: 360 °
Radius: 10 %
Exclusion
Offset . X: 0 m
Offset . Y: 0 m
Offset . Z: 0 m
Dimension . X: 200 m
Dimension . Y: 120 m
Dimension . Z: 200 m

▶ **Move the In Beer drag cube so that its top is just below the bottom of the Enter Beer drag cube.**

Position the In Beer drag object as illustrated here.



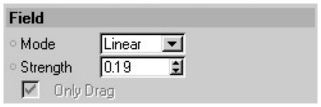
We wish to slow down the coin for only the main body of the beer, beyond this we need to stop it to prevent the coin leaving the glass.

▶ **Select Plugins > Dynamics > Drag. Double-click on the Drag name in the Object manager and set the name to End Beer, then drag End Beer into the solver.**

To give the impression of the coin coming to rest at the bottom of the glass we need a drag object that can stop the motion.

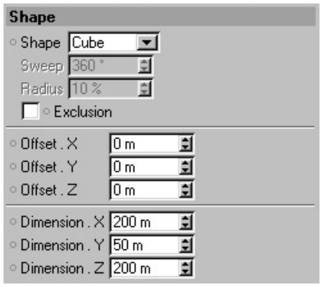
▶ **Click the Field tab for the End Beer object and set the Strength to 0.19.**

Reducing the strength of the drag will change it from a thick goo into a smooth pint of beer.


Field
Mode: Linear
Strength: 0.19
Only Drag ✓

► **Click the Shape tab and set the Shape to Cube and Dimension.Y to 50.**

Fake the displacement of the beer by telling the drag to cover only the bottom of the glass.

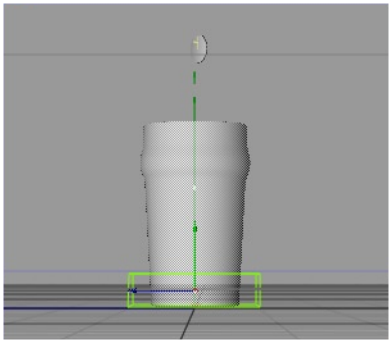


Shape

Shape: Cube
Sweep: 360 °
Radius: 10 %
Exclusion
Offset . X: 0 m
Offset . Y: 0 m
Offset . Z: 0 m
Dimension . X: 200 m
Dimension . Y: 50 m
Dimension . Z: 200 m

► **Move the End Beer drag cube so that its bottom is at the bottom of the glass.**

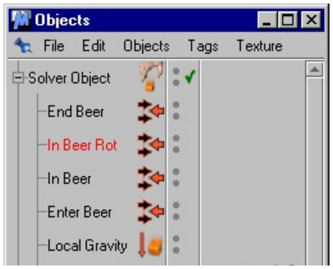
Position the drag field so that it is overlapping the bottom of the glass.



This will stop the object moving. Play it to see how it looks … but the fall is not yet complete. We now want the coin resting approximately flat at the bottom of the glass.

► **Making sure you have your Object manager open and the In Beer object selected, select Edit > Copy in the Object manager, followed by Edit > Paste. Double-click this new In Beer object's name and set the name to In Beer Rot.**

A duplicate of this drag is needed to alter the rate at which it rotates. This is known as an 'angular' drag.

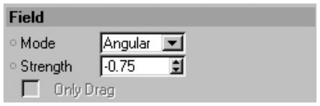


Solver Object
End Beer
In Beer Rot
In Beer
Enter Beer
Local Gravity

We want to use the same position and shape for our next drag object as we did for the main body drag, so it is easier to simply copy and paste this object and then modify it.

▶ **Click the Field tab for the In Beer Rot object and set the Mode to Angular and the Strength to -0.75. Drag the In Beer Rot object into the solver.**

The drag type needs switching from Linear to Angular.


Field
Mode: Angular
Strength: -0.75
Only Drag: ☐

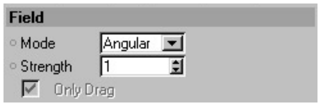
To make the coin spin around and land at the bottom of the glass we need to increase any rotation it has already. This can be used to give the illusion that an object that appears to be not rotating has its motion changed, but we are in fact simply speeding it up enough so that the coin orients to a flat position as it leaves the angular drag.

▶ **Making sure you have your Object manager open and the End Beer object selected, select Edit > Copy, followed by Edit > Paste, then double-click this new End Beer object's name and change it to End Beer Rot.**

Again we want to use the same position and shape for our new drag object as we did for the end drag.

▶ **Ensure you have the End Beer Rot object selected. Click the Field tab and set Mode to Angular and Strength to 1. Drag the End Beer Rot object into the solver.**

The duplicate drag needs to be set to Angular to stop the coin rotating when it comes to a stop.


Field
Mode: Angular
Strength: 1
Only Drag: ☑

To stop the coin spinning and to make it land at the bottom of the glass we need to stop any rotation as well as any linear motion. The two End Beer drags will stop all motion of the coin.

▶ **Click Play and then click Stop when you are finished.**

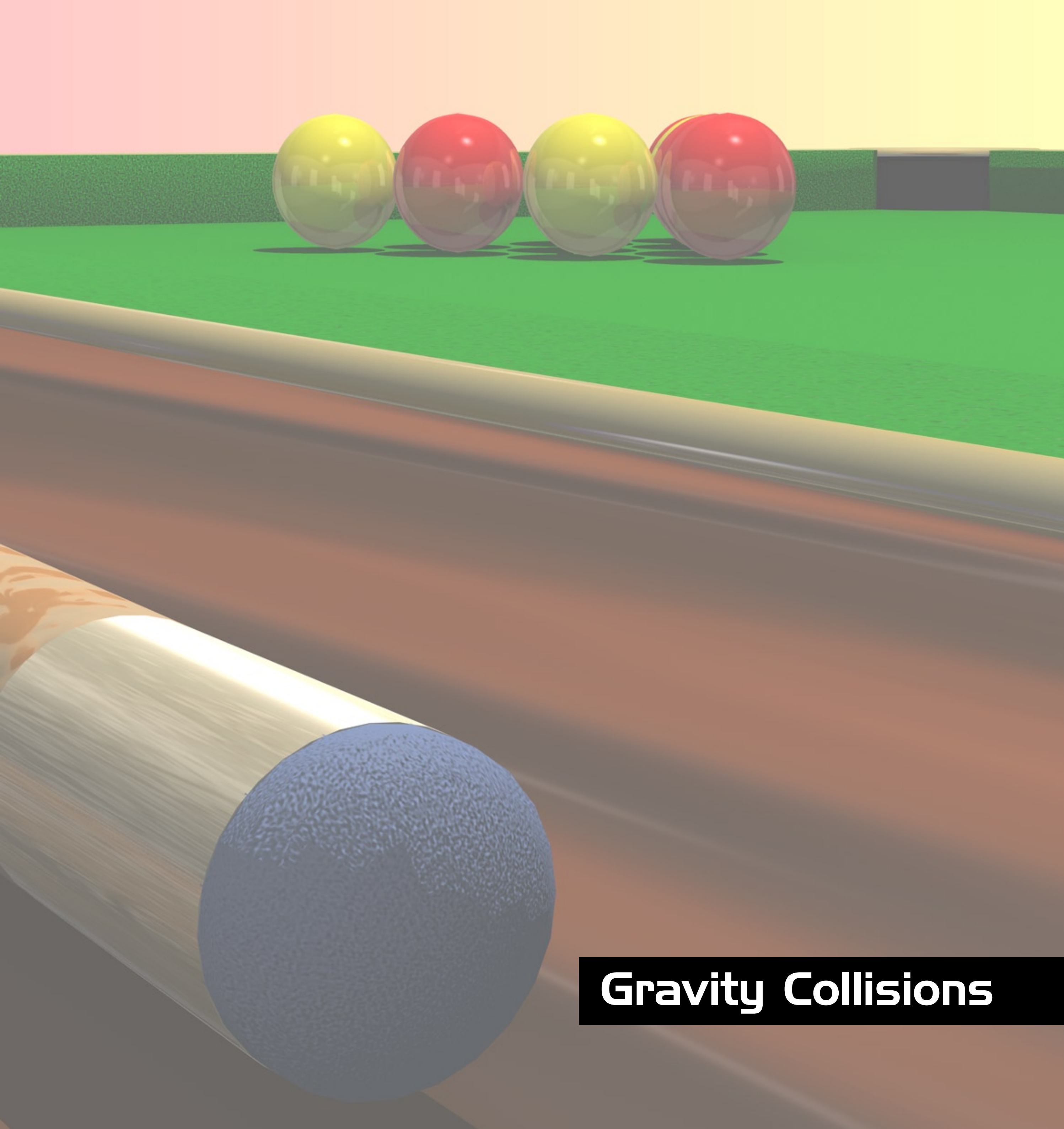
The coin should fall into the beer, be slowed as it enters, followed by a gentle fall through the beer with a slow rotation, finally rotating at the bottom to land and sit at the bottom of the glass.

Summary

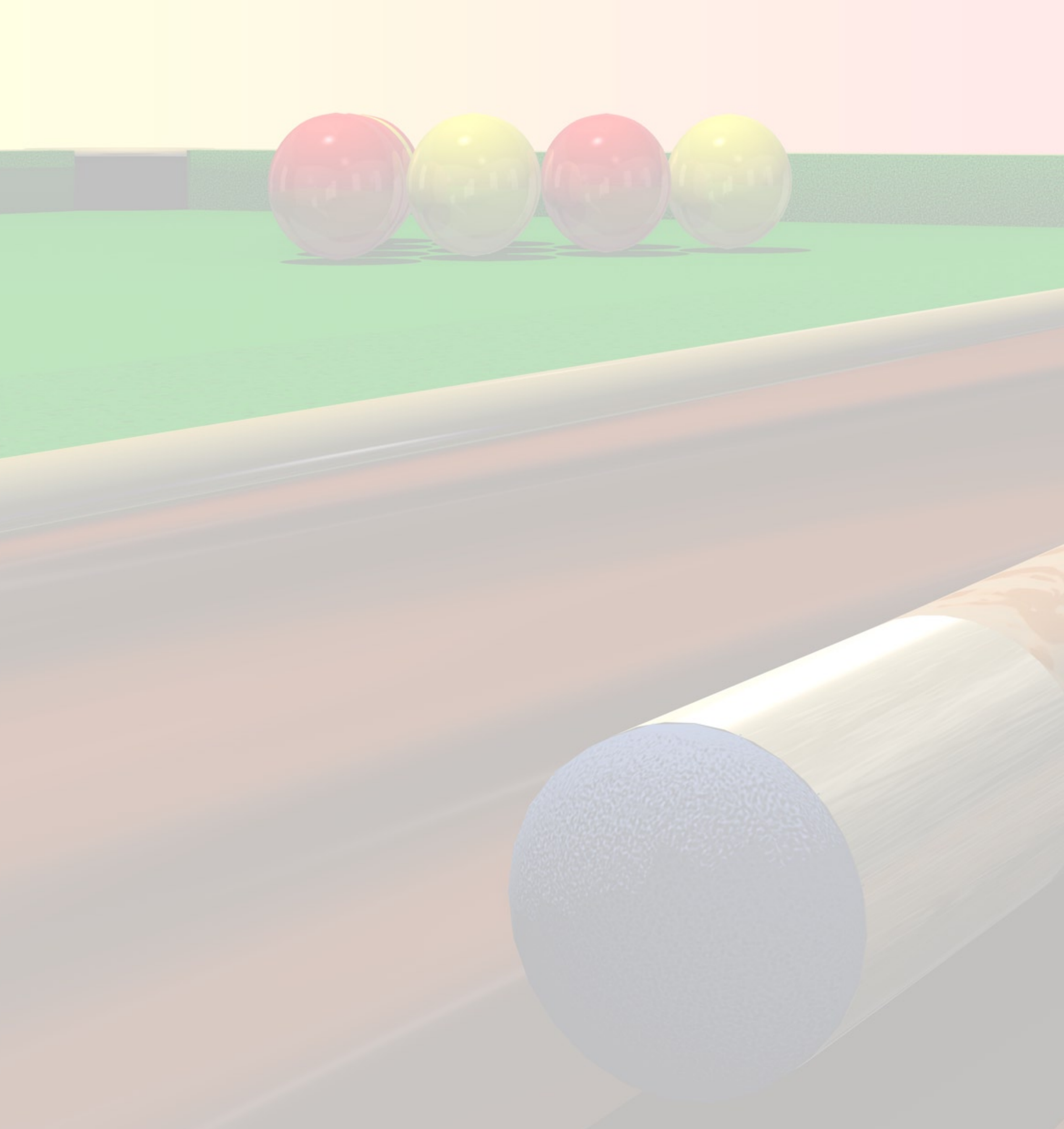
You may find that your motion isn't exactly the same as the one shown in the diagrams or in the finished animation in the Motion With Drag tutorial folder ('mwdfinal.c4d'). This will apply to all dynamics, the exact motion depends on the positions and values we set, and as such we need to become accustomed to adjusting scenes and values to give us the motion we require.

You can adjust the values slightly to slow or speed up the fall and rotation; the final resting orientation of the coin slightly depends on the positions of the drag objects.

Although this scene isn't fully realistic — the surface of the beer remains still even though a coin struck it — we will return to it in later tutorial to add a liquid-like surface using soft bodies.



Gravity Collisions



Gravity Collisions

Using full collision detection is not always essential to a working dynamics animation. To save processing time, carefully constructed scenes can use gravity to create a simplified repulsion instead.

Full-blooded collision detection takes a lot of processing. The more objects there are in our scene, the more motion has to be checked and re-computed for every frame, keeping in mind that if one object hits another and causes it to move, then not only does the new movement have to be calculated but new checks have to be made to see if the object which has been shunted is now going to interact with anything else. And so on until every object in the scene has reacted, or not, to the initial collision.

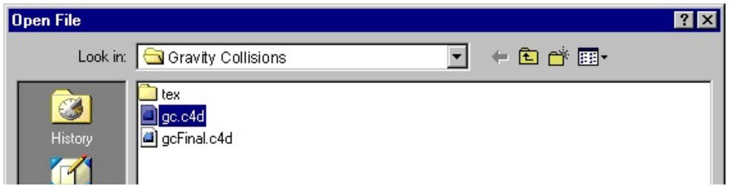
With complex scenes, all you can do is throw gigahertz at the problem.

Or is it? Does every collision have to be an accurate simulation of real-world dynamics? If we can fudge it so that it looks real enough and save ourselves days of computation, isn’t that worth it?

Of course it is. In this tutorial we will be looking at one way in which collisions can be simulated cheaply. While we may need to spend a little extra time setting up the scene, with clever use of gravity we can make objects ‘bounce’ off each other realistically and it will cost us a lot less processing time.

▶ **Select File > Open. Navigate to the Gravity Collisions tutorial folder on your Documentation CD and open the file named 'gc.c4d'.**

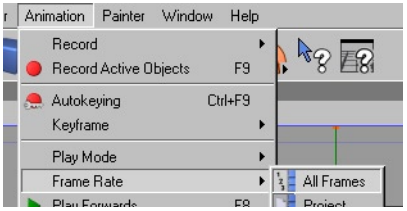
Open the gc.c4d file for a ready-made pool table. The Tutorials folder is in the Dynamics module folder. Each tutorial has its own folder within the main Tutorials folder.



The scene objects are now available in the Object manager. We now want to make the balls interact with the cue and table, and of course each other.

▶ **Ensure that Animation > Frame Rate > All Frames is enabled.**

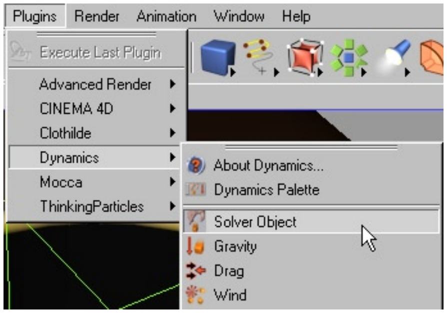
When working with Dynamics we should always ensure that CINEMA 4D is set to display every frame.



When using dynamics we need to be able to see every frame; this enables us to check that every frame is how we want it to look, plus it prevents the dynamics from calculating many frames at once, which can be slow on some complex scenes. When working with dynamics we should make it a habit to ensure that All Frames is enabled.

▶ **Select Plugins > Dynamics > Solver Object.**

Without the Solver object models cannot be moved by Dynamics.



A Solver object will appear in the Object manager; this object is where we will add the objects that we want to interact through dynamics and is necessary for any dynamics system to work.

▶ **Click the Main tab and set the Stop frame to 300.**

We want the animation to last the length of our timeline, so we set the stopping frame for the dynamics to the end frame on our timeline.

▶ **Leave the Integration Method to Adaptive. Set the Oversampling to 8 and the Subsampling to 8.**

When the balls initially collide there will be many collisions to calculate as they ricochet off one another. If Midpoint calculations were used then there is a chance that one of the balls may intersect another. By using Adaptive we can specify a subsampling which will be used to further divide the frames when it becomes necessary.

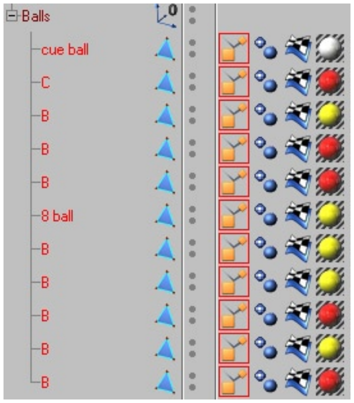
▶ **Set the Energy Loss to 3.**

After we strike the balls they will eventually come to a stop due to the friction of both the air and the table surface. Energy Loss will simulate this by gradually slowing down all of the balls.

Command-click on a Mac if you have only one mouse button.

▶ **In the Object manager, open the Balls group. Select all child objects of 'Balls'. Right-click on one of the selected balls then select Dynamics Tags > Rigid Body Dynamic.**

Adding Rigid Body Dynamic tags is needed to assign each ball a mass. Without mass, no calculations can be made.



For our collisions we will need each ball to be a solid object with a mass; this enables us to make use of the dynamics force objects.

▶ **Select Plugins > Dynamics > Gravity and drag the Gravity object and the Balls group into the solver. Double-click on the Gravity object's name, rename it Collisions, then click OK.**

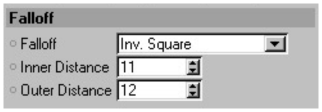
For our collisions we'll use a Gravity object to enable our balls to interact.

▶ **Click the Field tab and set the Strength to -4000000 and the Mode to Newton.**

Setting a massive negative strength for gravity will make it appear as though nothing can enter the gravity field; anything that comes near will bounce away immediately.

▶ **Click on the Falloff tab, set the Falloff to Inv. Square, the Inner Distance to 11 and the Outer Distance to 12.**

Gravity collisions are almost always faster to calculate, and in this case will give convincing enough results.



Falloff

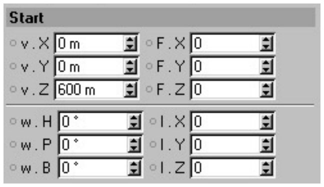
Falloff	Inv. Square
Inner Distance	11
Outer Distance	12

For our collisions we want each ball to be repelled if any other ball comes within range, so that they appear to collide. To reduce any unpredictable collisions we use a thin falloff shell to soften the impact slightly as the balls start to collide.

The Inner Distance and Outer Distance values are set so that, as the centres of mass of both balls come within the diameter of the balls with which they collide, it appears that the outer geometry has collided.

▶ **Click on the Cue Ball object's Rigid Body Dynamic tag. Click the Start tab and set v.Z to 600.**

We'll start off simply by making the cue ball move by itself.



Start

v.X	0 m	F.X	0
v.Y	0 m	F.Y	0
v.Z	600 m	F.Z	0
w.H	0 °	I.X	0
w.P	0 °	I.Y	0
w.B	0 °	I.Z	0

▶ **Click Play and then click Stop when you are finished.**

We can now check to see if our balls interact in a manner we are happy with. The cue ball should move up the pool table and strike the first red ball, which will strike into the pack of balls and scatter them gently at the top of the table.

▶ **Select Plugins > Dynamics > Gravity and drag the Gravity object into the solver.**

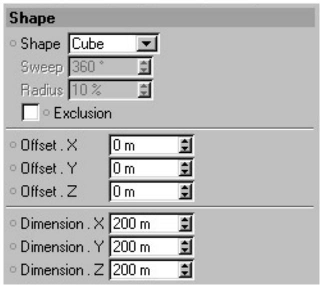
▶ **Double-click on the Gravity object's name and rename it Top-Left Border.**

To make the balls interact with the table we need to give the illusion of the cushions situated around the edges of the table. For this purpose we can use further Gravity fields to repel the balls as they come within range of the table edges.

▶ **Click the Field tab for Top-Left Border, set the Strength to -100, Direction.X to -1 and the other Direction values to zero.**

▶ **Click the Shape tab and set the Shape to Cube.**

Using a cube of gravity we can fake a collision with the cushion by suddenly repelling the ball.



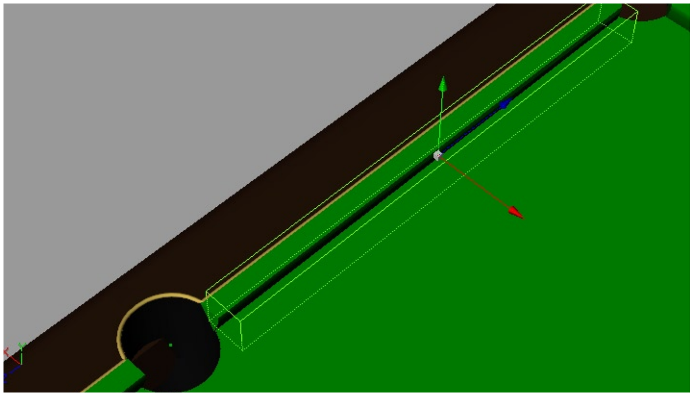
Shape

Shape	Cube
Sweep	360 °
Radius	10 %
Exclusion	☐
Offset . X	0 m
Offset . Y	0 m
Offset . Z	0 m
Dimension . X	200 m
Dimension . Y	200 m
Dimension . Z	200 m

By using an axial cube of gravity we can place a border around the table which will stop the balls from leaving the confines of the table. We need the direction of the axial gravity to always point inwards towards the table, which is why we set Direction.X to -1.

▶ **Scale (Use Object Tool) and position the cube of gravity into a thin cuboid shape along the top-left cushion between the middle and top pockets.**

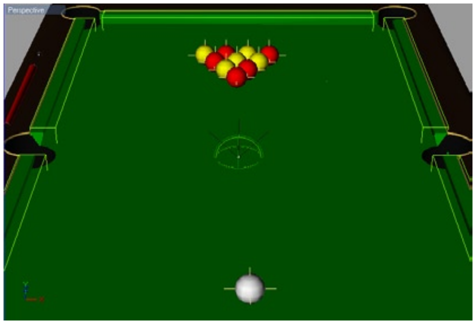
Position the cube of gravity so that it is more or less in the same position as the cushion.



By placing this cube as a border we can make the cushions appear to interact with balls that come within the cube of gravity. The balls will interact only once a ball’s centre of mass enters the cube of gravity, so we must ensure we position the cube far enough inside the table so that the geometry of the ball and cushion don’t penetrate.

▶ **Copy and paste the Top-Left Border Gravity object to create the borders around the table for each piece of cushion between the pockets — six in total. As you paste them, rename each copy accordingly.**

Create five more cushions by duplicating the original one. How you rotate these will affect the sign (+ or -) of the axial gravity (see main text).



We will need to rotate the gravity by 90 degrees in the relevant directions to create the top and bottom cushions. Ensure that the red axis of each gravity object points inwards towards the table (this will save us from having to change the direction of the axial gravity on the Field tab).

By placing the gravity objects around the table we have a fully interacting table so that the balls will bounce off the cushions and off each other.

▶ **Select Plugins > Dynamics > Gravity and drag the Gravity object into the solver.**

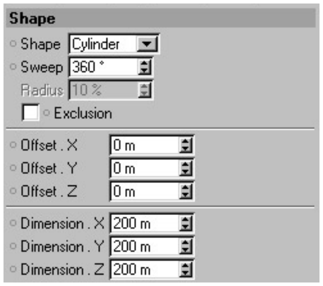
▶ **Double-click on the Gravity object's name and rename it Top-Left Pocket.**

To make the balls fall into the pockets we need to add additional gravity objects, otherwise the balls will leave the table through gaps in the border gravity objects.

▶ **On the Field tab for the Top-Left Pocket Gravity object, set Strength to 20.**

▶ **Click the Shape tab and set the Shape to Cylinder.**

We're aiming to pot at least one ball, so gravity is needed over each hole.



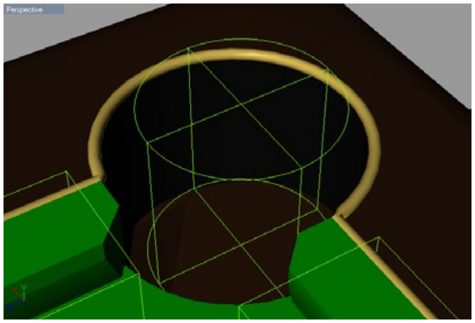
Shape

Shape	Cylinder
Sweep	360 °
Radius	10 %
☐ Exclusion	
Offset . X	0 m
Offset . Y	0 m
Offset . Z	0 m
Dimension . X	200 m
Dimension . Y	200 m
Dimension . Z	200 m

The Gravity object needs to be shaped so that as the ball enters the pocket it will be forced downwards, giving the impression of it falling.

▶ **Scale and position the pocket's gravity cylinder so that it is slightly smaller than the diameter of the top-left pocket.**

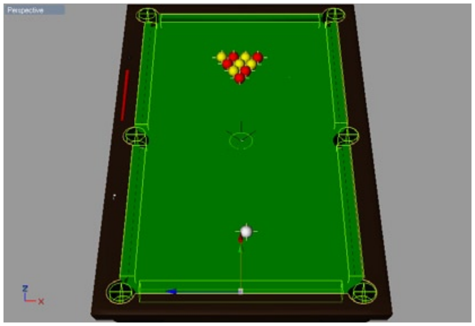
The cylinder of gravity needs to be scaled and positioned accordingly.



We need to place the gravity so that as a ball's edge begins to leave the surface of the table, it will begin to fall; this will help to stop the edge of the ball falling through the table.

▶ **Copy and paste the top-left pocket's gravity object to create the gravity for the other pockets.**

Just as we did with the cushions, replicate five more gravity fields and place them inside each hole.



▶ **Click Play and then click Stop when you are finished.**

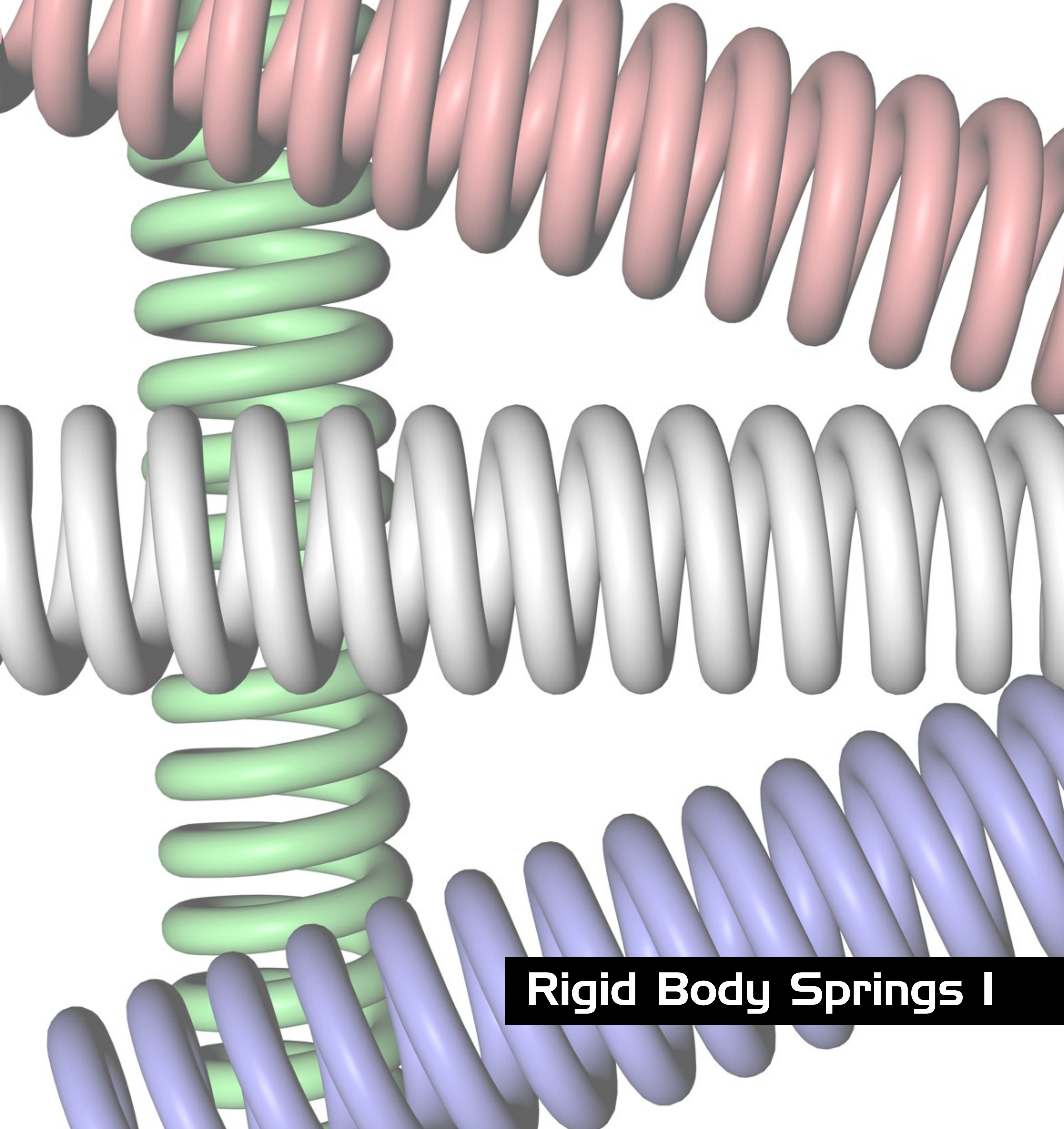
The Cue Ball should move up the table and collide as before, but this time the balls should also bounce around the inside of the table.

Summary

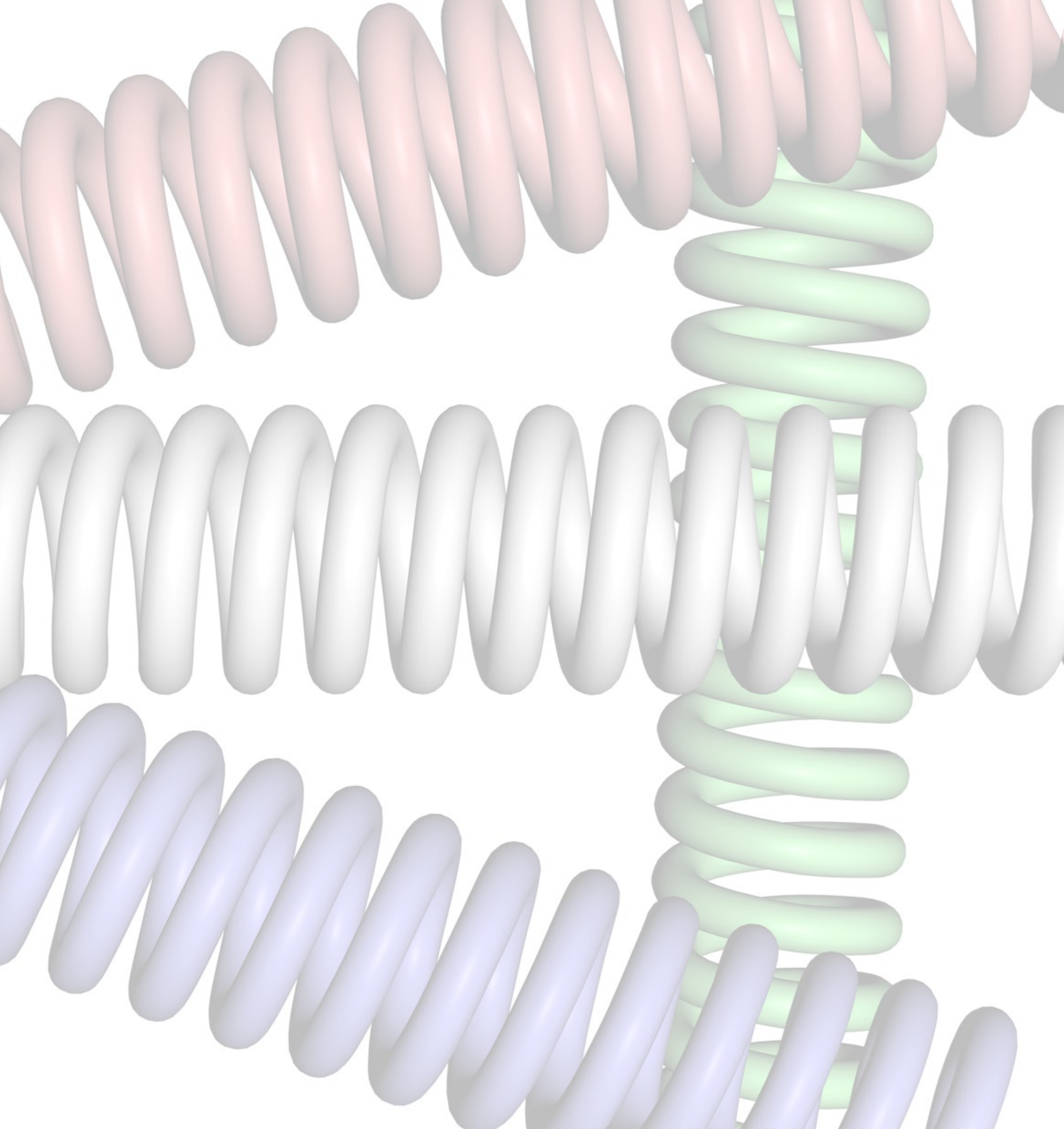
Try changing the cue ball's v.X value on the Start tab in the Rigid Body dialog and see if you can pot a ball. This illustrates the flexibility of Dynamics, once the scene is created we can continue to adjust the object interactions without needing to adjust the whole animation, the dynamics will handle it for us. We can take this one step further, we can introduce keyframing into the dynamics. There are a number of ways to use keyframes; we can use them on objects with a zero mass, or on the children of dynamics objects.

One thing you should always bear in mind when creating a simulation is how much the viewer will see. In this tutorial you may have noticed that none of the balls actually roll. Of course it is possible to make this happen using real collisions and friction, but if the end viewer cannot tell, then there is no reason not to use a quicker method, such as these gravity force fields.

In the finished scene in the Gravity Collisions tutorial folder ('gcfinal.c4d') we have included a simple cue object; you can try use keyframing to move the cue and make it strike the cue ball, rather than moving the cue ball itself.

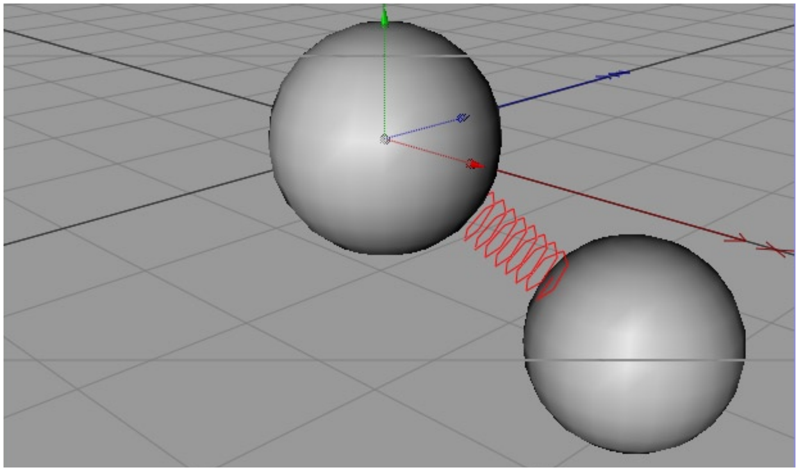


Rigid Body Springs I



Rigid Body Springs 1

Springs are an important feature of Dynamics and have more uses than you might imagine. In this tutorial we will illustrate how springs are applied.



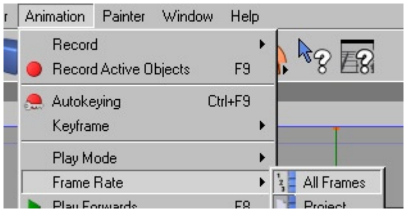
Rigid body springs are an invisible link between two or more objects that can either pull or push each other. We can compress a spring, to simulate the suspension of a vehicle for example, or stretch one, perhaps to create a catapult. Springs are represented in the CINEMA 4D viewports by a coiled line which looks (we hope) like a spring. Just like real springs, we can ruin them by overstretching; if this happens then they will lose much of their elastic properties and become more like a plastic material.

It is even possible to break springs by pulling on them too hard!

By increasing the stiffness of springs we can create a simple link that can hold two objects together. Springs also have the ability to rotate an object; think of a flat, tightly coiled spring in anything clockwork.

▶ **Ensure that Animation > Frame Rate > All Frames is enabled.**

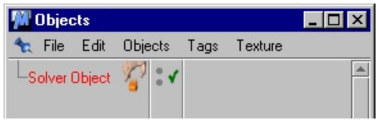
If a scene is too complex to handle in realtime, frames may be dropped. Avoid this by forcing the display of all frames.



When using dynamics we need to be able to see every frame; this enables us to check that every frame is how we want it to look, plus it prevents the dynamics from calculating many frames at once, which can be slow on some complex scenes. When working with dynamics we should make it a habit to ensure that All Frames is enabled.

▶ **Select Plugins > Dynamics > Solver Object.**

Solver objects are used to specify which objects are calculated; we are allowed to have more than one.



A Solver object will appear in the Object manager; this object is where we will add the objects that we want to interact through dynamics and is necessary for any dynamics system to work.

▶ **On the Solver object's Main tab set the Integration Method to Midpoint and decrease the Oversampling to 2.**

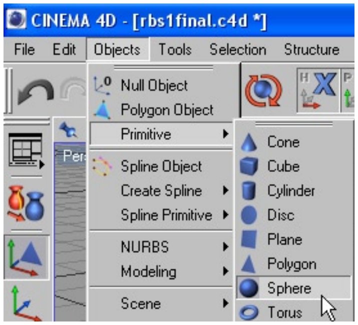
Midpoint calculations are the quickest available. As no accuracy is needed in this scene it can quite safely be used. Reducing the Oversampling will give us a further boost of speed.

▶ **Leave the Energy Loss set to 1.**

To bring the simulation to an eventual stop it needs to lose energy at some point. By giving it an overall energy loss, it cannot keep going forever.

▶ **Select Objects > Primitive > Sphere, twice.**

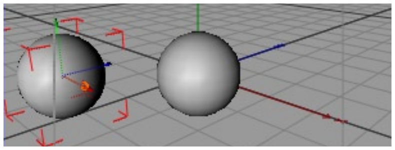
We will use simple spheres for our springs example as they are very quick to draw in the viewport.



This adds two spheres into the scene. We will link these two objects with a spring as soon as we have prepared them.

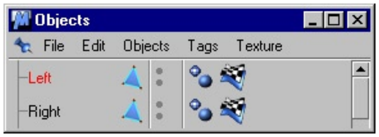
▶ **Move one of the spheres to the left so that it is separated from the other, as illustrated in the picture below.**

Move the spheres apart so that the spring, when we add it, can pull them together.



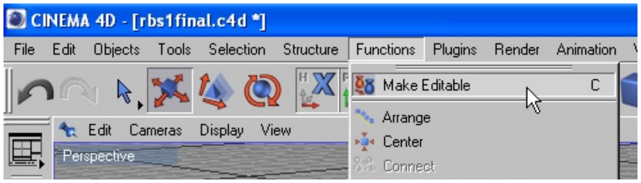
▶ **In the Object manager, double-click on the name of each of the spheres in turn and name them Left and Right accordingly.**

To help differentiate between the two spheres we are giving them logical labels.



▶ **In the Object manager, select both spheres (Shift-click to multi-select) and select Functions > Make Editable.**

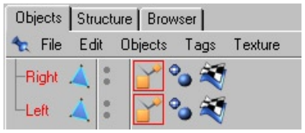
Dynamics cannot work on primitive objects, so convert them to polygons to continue.



Remember that all objects you want to be affected by dynamics must be polygon objects. This function will convert the parametric sphere (indicated by a dark blue sphere icon next to its name) into a polygon object (indicated by a light blue triangle icon by its name) as is required by Dynamics.

▶ **In the Object manager, select the two spheres and select File > Dynamics Tags > Rigid Body Dynamic.**

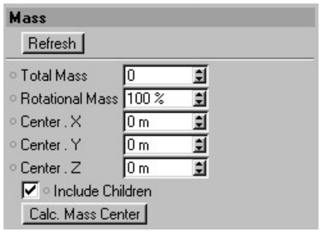
Dynamics needs to know the mass of an object in order to calculate its motion. A Rigid Body Dynamic tag enables us to add this mass.



This gives our spheres a Rigid Body tag each so that Dynamics knows that it should be calculating its position and rotation. A new icon will appear to the right of each sphere's name, this is the Rigid Body Dynamic tag. You will also see tags' settings appear in the Attribute manager.

▸ **Click on the Right sphere's Rigid Body Dynamic tag, click the Mass tab and set the Total Mass to 0.**

Set the mass to 0 to stop an object from falling under the influence of gravity.



Mass

Refresh

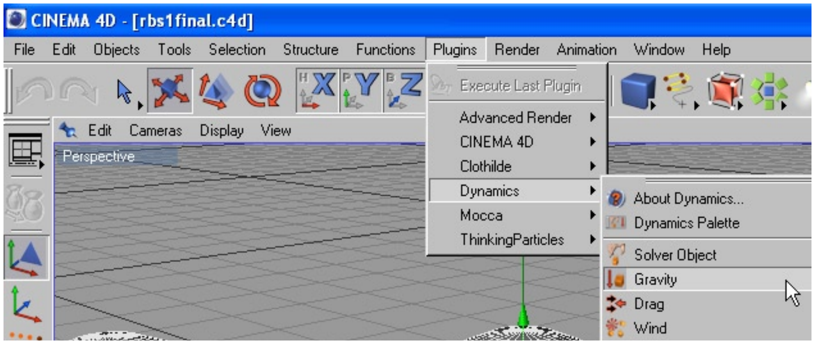
Total Mass	0
Rotational Mass	100 %
Center . X	0 m
Center . Y	0 m
Center . Z	0 m

☑ Include Children

Calc. Mass Center

▸ **Select Plugins > Dynamics > Gravity.**

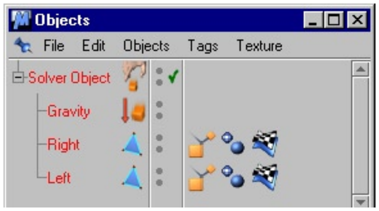
To make our spheres move, we need to add a force, in this case gravity.



One of the last things that needs doing before we add our springs is to add some gravity in order to make our spheres move.

▸ **In the Object manager, drag both spheres and the gravity into the solver.**

We are dropping the gravity and spheres into the solver so that dynamics can be applied to them.

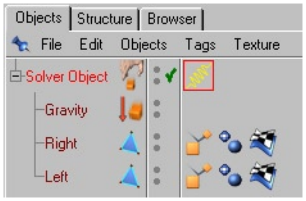


▸ **Click Play and click Stop when you are finished.**

You should see the left-hand sphere drop to the ground and the right-hand one remain stationary. This is because the right-hand one has no mass, so therefore cannot fall.

▶ **In the Object manager, select the Solver object then select File > Dynamics Tags > Rigid Body Spring.**

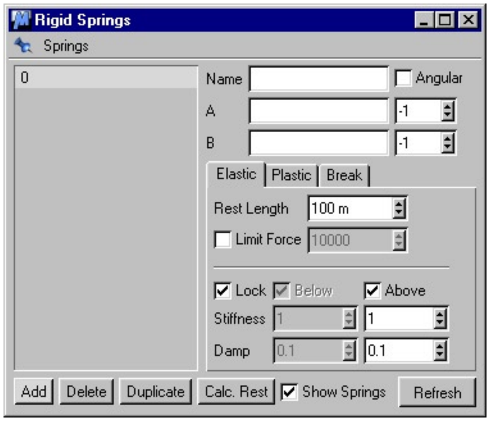
Springs can range from rigid suspension springs to loose rubber bands.



Now its time to give our spheres a more interesting motion by adding a spring between them. Rigid springs are created within a Rigid Body Spring tag. When adding a new Rigid Body Spring tag you will automatically be shown the Rigid Springs dialog.

▶ **In the Rigid Springs dialog, click the Add button.**

Add a single spring between the two spheres.



0

Name: [ ] Angular: ☐
A: -1
B: -1
Rest Length: 100 m
Limit Force: ☐ 10000
Lock: ✓ Below: ✓ Above: ✓
Stiffness: 1 1
Damp: 0.1 0.1
Show Springs: ✓

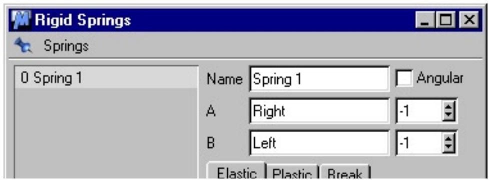
This begins the process of adding a spring between the two objects. Some boxes will become active at the top of the dialog.

▶ **Set the name to Spring 1.**

It is a good idea to get into the habit of naming your springs just as you would name objects in a project.

► **Set A to Right and set B to Left.**

We set A and B to specify which objects we wish to join with this spring.



Name: Spring 1
Angular: ☐
A: Right -1
B: Left -1

The A and B boxes are the names of the two objects you wish to join. We entered in the names Left and Right because this is what we named them earlier.

On the right-hand side of A and B you will see another two input boxes, both reading -1. The number in these boxes decides which point number the springs will attach to. The number -1 is a special number which tells Dynamics to connect the spring to the object's origin.

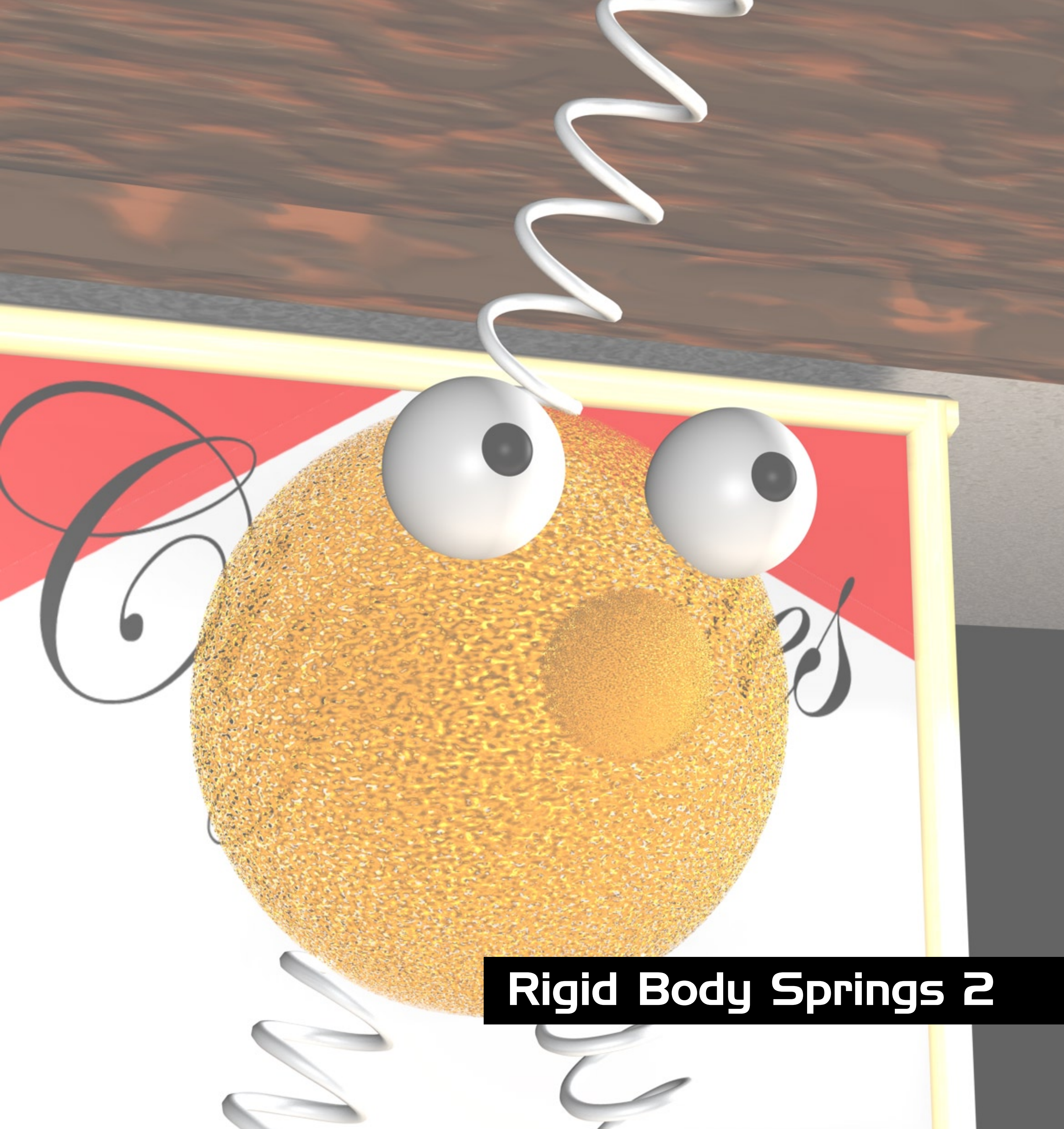
► **Click Refresh and close the Rigid Springs dialog.**

► **Click Play and click Stop when you are finished.**

You will now see the two spheres interacting, thanks to the spring.

Summary

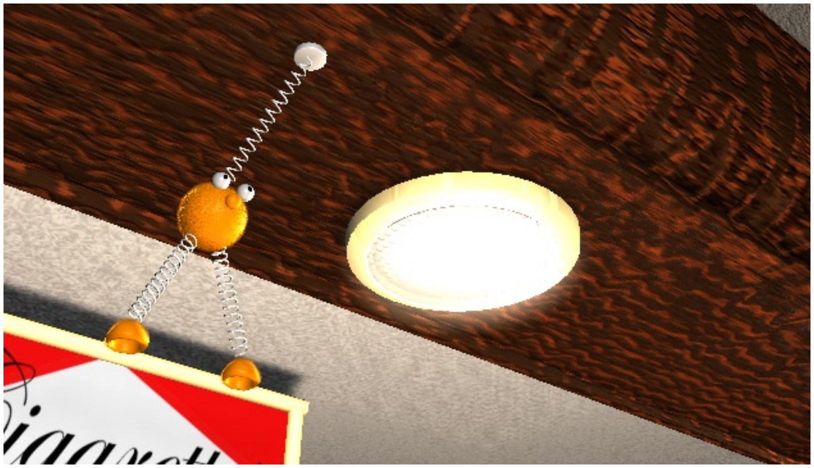
Now we know how to apply a simple spring. We have not yet looked into changing the stiffness or damping of the spring, both of these areas will be covered and explained next in Rigid Body Springs 2. We recommend you head straight on into this second springs tutorial where you will be able to start having some fun with them on our bouncy character.



Rigid Body Springs 2

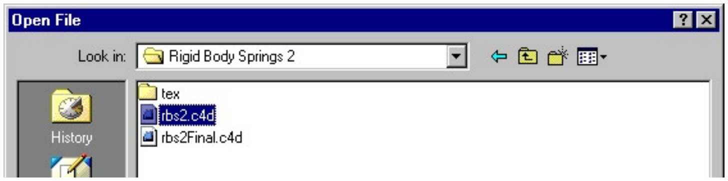
Rigid Body Springs 2

In this tutorial we will be applying what we learned in Rigid Body Springs 1 to a real scene. The end result will be a bouncy advertising mascot which illustrates the sudden release of stored energy.



► **Select File > Open. Navigate to the Rigid Body Springs 2 tutorial folder on your Documentation CD and open the file named 'rbs2.c4d'.**

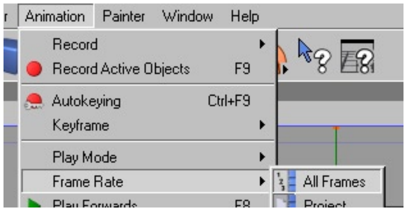
Open the bar scene from the Tutorials folder, this has everything we need to get started.
The Tutorials folder is in the Dynamics module folder. Each tutorial has its own folder within the main Tutorials folder.



You will see four objects in the Object manager: Top, Body, Rfoot and Lfoot (Body is actually a group of objects, but it will be treated as one).

► **Ensure that Animation > Frame Rate > All Frames is enabled.**

Depending on your computer, it may not be able to maintain a steady 25 fps. All Frames will avoid the danger of any frames being skipped.



When using dynamics we need to be able to see every frame; this enables us to check that every frame is how we want it to look, plus it prevents the dynamics from calculating many frames at once, which can be slow on some complex scenes. When working with dynamics we should make it a habit to ensure that All Frames is enabled.

► **Select Plugins > Dynamics > Solver Object.**

A Solver object will appear in the Object manager; this object is where we will add the objects that we want to interact through dynamics and is necessary for any dynamics system to work.

► **On the Main tab set the Stop frame to 1000, the Integration Method to Midpoint and the Oversampling to 2.**

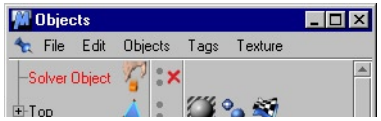
In this tutorial we are making a springy pub mascot bounce around randomly. This means that there is almost no need for accuracy because it can't really go wrong. Setting the calculations to Midpoint and the Oversampling to 2 means the least processing power is required. Increasing the stop frame to 1000 ensures the simulation does not stop prematurely.

► **Set the Energy Loss to 1.**

Rather than add a Drag object to the scene for air resistance, we will instead set a global energy loss. This means that the whole simulation is constantly losing energy, which will cause the springy character to eventually come to a rest.

► **Click on the green tick next to the Solver object to disable it.**

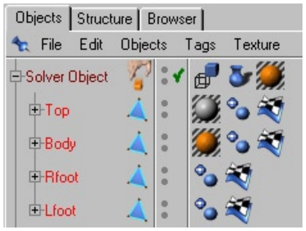
We can tell a Solver object not to affect a scene by disabling it in the Object manager.



It is a good idea to turn off the Solver object so that it does not have an effect on the scene until we are ready for it to.

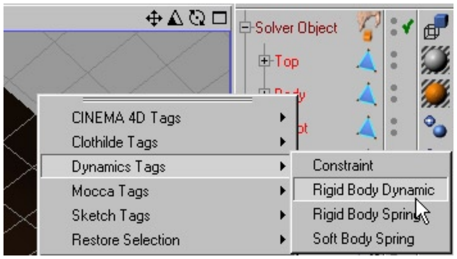
► **In the Object manager, drag the four objects (Top, Body, Lfoot, Rfoot) into the Solver object.**

These objects will make up the head, feet and link of our springy character.



► **In the Object manager, select the four objects (Top, Body, Lfoot, Rfoot) and then select File > Dynamics Tags > Rigid Body Dynamic.**

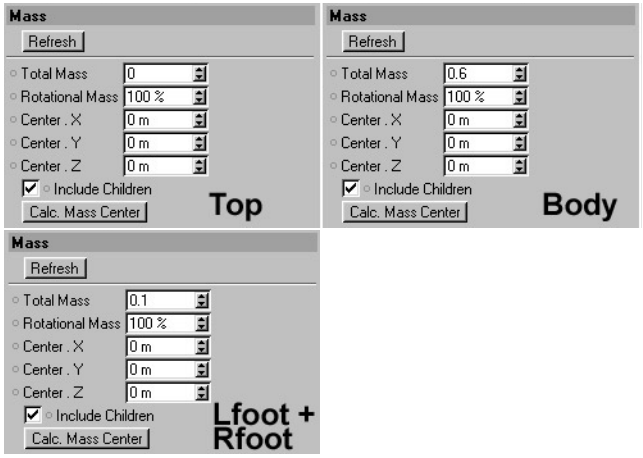
All Dynamics objects must have either a Rigid or Soft Body tag.



This adds a Rigid Body Dynamic tag to each of the four objects and will allow Dynamics to influence them.

► **Click on each Rigid Body Dynamic tag one after the other and on the Mass tab, set the Total Mass as follows: Top = 0, Body = 0.6, Lfoot and Rfoot = 0.1.**

DIfferent masses for different objects.
We can nail an object in place by giving it a mass of 0.
Only keyframes can move such objects.



Top

Total Mass	0
Rotational Mass	100 %
Center . X	0 m
Center . Y	0 m
Center . Z	0 m
Include Children	✓

Body

Total Mass	0.6
Rotational Mass	100 %
Center . X	0 m
Center . Y	0 m
Center . Z	0 m
Include Children	✓

Lfoot + Rfoot

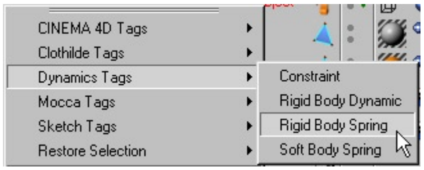
Total Mass	0.1
Rotational Mass	100 %
Center . X	0 m
Center . Y	0 m
Center . Z	0 m
Include Children	✓

A mass of 0 guarantees that the Top object will not fall down when we later add gravity to the scene. As the feet are the smallest objects, they will also be the lightest, hence the low mass of 0.1.

Command-click on a Mac if you have only one mouse button.

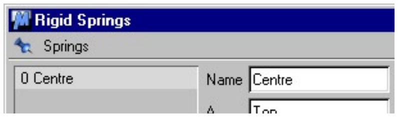
▶ **In the Object manager, right-click on the Solver object and select Dynamics Tags > Rigid Body Spring.**

The Rigid Body Spring tag must be assigned to the Solver object.



▶ **In the Rigid Springs dialog, click the Add button to create a spring and set its Name to be Centre.**

We can create as many springs between whichever objects we like.

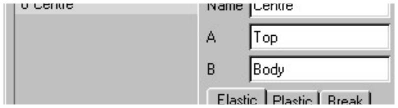


Rigid Springs
Springs
0 Centre
Name Centre

This will help later on if we need to know which spring is which.

▶ **Set A to Top and B to Body. Note that these names are case-sensitive!**

Just like the objects in the Object manager, we should name our springs to help us remember what they are for.

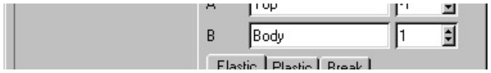


A Top
B Body
Elastic | Plastic | Break

The A and B values in this dialog determine which two objects will be linked; as this is the main centre spring we need to connect it between the Top and Body objects.

▶ **Set the box to the right of B to 1.**

Each spring must be linked to another object; here we are linking the two spheres.



B Body 1
Elastic | Plastic | Break

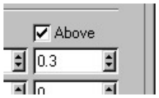
To the right of the A and B values are two further values which determine where the springs attach to the objects named in A and B. The first one can be left at -1 so that it connects to Top's origin. The second one is set to 1 so that it connects to the top of the Body object.

▶ **Set Rest Length to 200.**

The distance between the Top and Body objects is far greater than the default Rest Length of 100 units. So this value is increased to reduce the tension placed on the spring.

▶ **Set the Above Stiffness value to 0.3.**

We can reduce the strength of the springs to make them very loose.

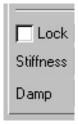


At the bottom of the Rigid Springs dialog are the Above and Below values. Above settings are applied when the spring is stretched past its rest length; Below settings come into effect when you compress the spring below its rest length.

By reducing the spring stiffness we are making the spring elasticity weaker so that it does not ping back as quickly.

▶ **Disable the Lock option.**

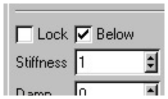
If the spring settings are locked then we will be restricted to using the same settings for when the spring is compressed and stretched.



The Below section is currently greyed out because the Lock option is enabled. When the Lock option is enabled you will be able to enter values only into the Above section.

▶ **Ensure that the Below Stiffness value is set to the default setting of 1.**

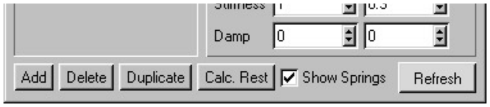
We may select different behaviours for when the spring is either stretched or compressed.



This will ensure that the spring cannot squash down very much.

▶ **Set the Damp value to 0 for both Above and Below.**

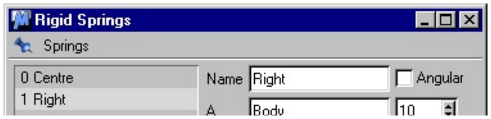
We don't want the spring's motion to die out; we can keep them moving by eliminating the Damp settings.



Damp is short for damping. We set it to zero so that the spring does not lose any energy by bouncing back and forth.

▸ **Click the Add button to create a new spring and set its Name to Right.**

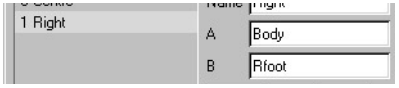
The springs for the feet need different settings from the main one connecting the body.


Rigid Springs
Springs
0 Centre
1 Right
Name Right
Angular
A Body 10

We are now adding a new spring for the body and right foot. This spring should be named Right as it will connect the right foot to the body.

▸ **Set A to Body and B to Rfoot.**

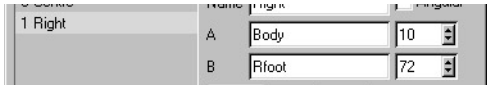
This time a new spring will be connected between the main body and the right foot.


1 Right
A Body
B Rfoot

Just as we did before, we have to tell Dynamics which two objects it should connect with this new spring.

▸ **Set the box to the right of A to 10 and the box to the right of B to 72.**

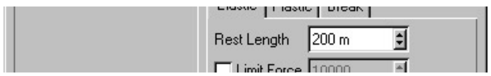
We have already found the correct points to connect for a realistic motion.


1 Right
A Body 10
B Rfoot 72

To keep the character's feet separate we need to attach them to the opposite sides of the body so that they do not end up dangling down in the same location. In this case, point number 10 of the Body object is on the bottom right-hand side and point 72 of the Rfoot object is at the very top. (If you select any point of an object, you can see what number it is in the Structure manager.)

▸ **Set the Rest Length to 200.**

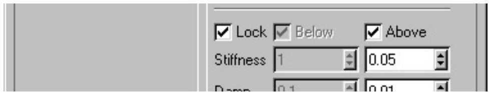
This spring is almost identical to the main spring, using the same rest length settings.


Rest Length 200 m
Limit Force 10000

The distance between the right foot and the body is almost the same as the distance between the body and the top, this means we can use the same rest length for the spring.

▸ **Set the Above Stiffness all the way down to 0.05.**

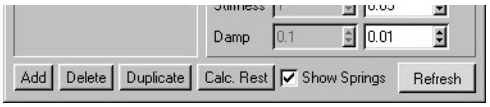
Reduce the default stiffness until it represents a very loose and slack spring.


☑ Lock ☑ Below ☑ Above
Stiffness 1 0.05

The feet are also very small and light; if we used the default spring stiffness then the feet would not bounce very much at all. We need to make the spring very loose.

► **Set the Above Damp to 0.01.**

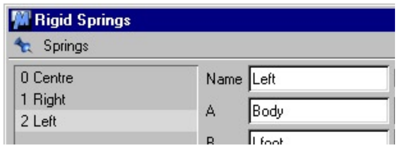
Because the feet are very light and loose, we need to make them lose some energy.


Damp 0.1 0.01

The damping on these springs will also need to be reduced so that they bounce for a longer period of time.

► **Click the Add button to create a new spring and set its Name to be Left.**

Individual springs are needed for each foot to act independently.



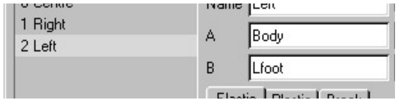
0 Centre
1 Right
2 Left

Name Left
A Body

We are now adding a new spring for the body and left foot.

► **Set A to Body and B to Lfoot.**

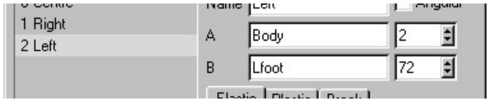
A rigid spring will be created between whichever two objects are in the A and B boxes.


1 Right
2 Left

A Body
B Lfoot

► **Set the box to the right of A to 2 and the box to the right of B to 72.**

The smaller boxes to the right of A and B decide which points of the object will be joined.

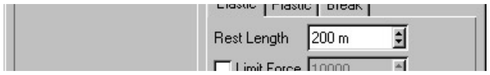

1 Right
2 Left

A Body 2
B Lfoot 72

To keep the character's feet separate we need to attach them to the opposite sides of the body so that they do not end up dangling down in the same location. In this case, point number 2 of the Body object is on the bottom left-hand side and point 72 of the Lfoot object is at the very top. (If you select any point of an object, you can see what number it is in the Structure manager.)

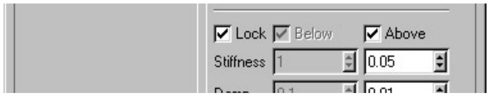
► **Set the Rest Length to 200.**

The rest length is the length that the spring will always try to become.


Rest Length 200 m

► **Set the Above Stiffness all the way down to 0.05.**

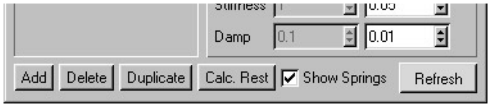
Just like the right spring, the left spring needs to have the stiffness reduced quite a lot.


✓ Lock ✓ Below ✓ Above

Stiffness 1 0.05

▶ **Set the Above Damp to 0.01.**

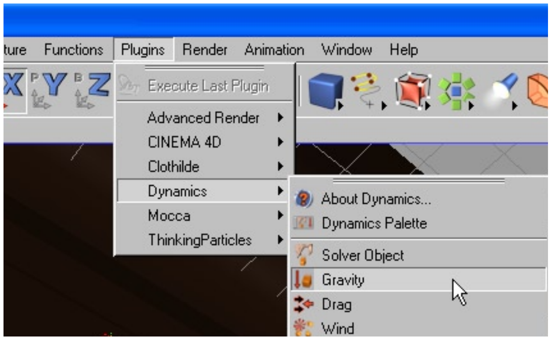
Damping can be used to calm down the motions of springs, simulating natural energy loss.



▶ **After you have entered the settings for all three springs, click on Refresh to save the settings. Close the Rigid Springs dialog as it is no longer needed.**

▶ **Select Plugins > Dynamics > Gravity.**

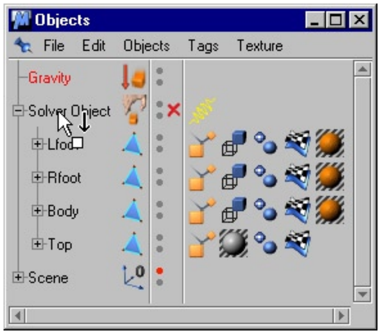
Without gravity our scene would look highly unrealistic.



A Gravity object is essential to this scene in order to pull the objects downwards; otherwise they would not bounce very convincingly. The default settings simulate earth's gravity so we do not need to open the dialog.

▶ **Drag the gravity into the solver.**

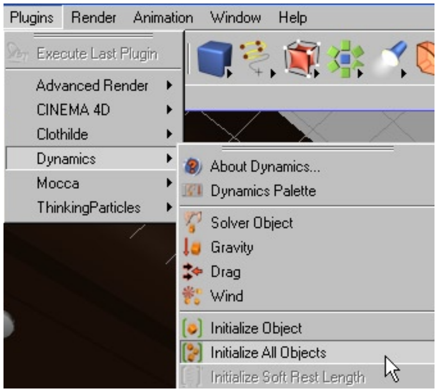
All forces we want to use in our simulation must be children of a Solver object.



Without Gravity in a simulation there is a high chance that it will appear to be in outer space, gravity is needed to pull the springs back down.

▶ **Select Plugins > Dynamics > Initialize All Objects.**

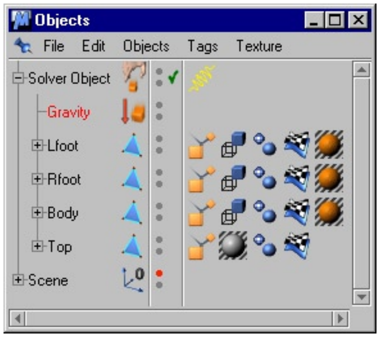
We should always initialise a scene before enabling a Solver object.



Now that we have everything in place we need to initialise all the objects. This will cause the Solver object to take note of all positions and use them for the start positions of the simulation.

▶ **Enable the Solver object by clicking on its red cross.**

Springs enabled, Dynamics requires an active Solver object to calculate the simulation.



The Solver now has all the new coordinates for the objects so it is safe to re-enable it. The simulation will only take place if the Solver object is switched on by displaying a green tick next to its name.

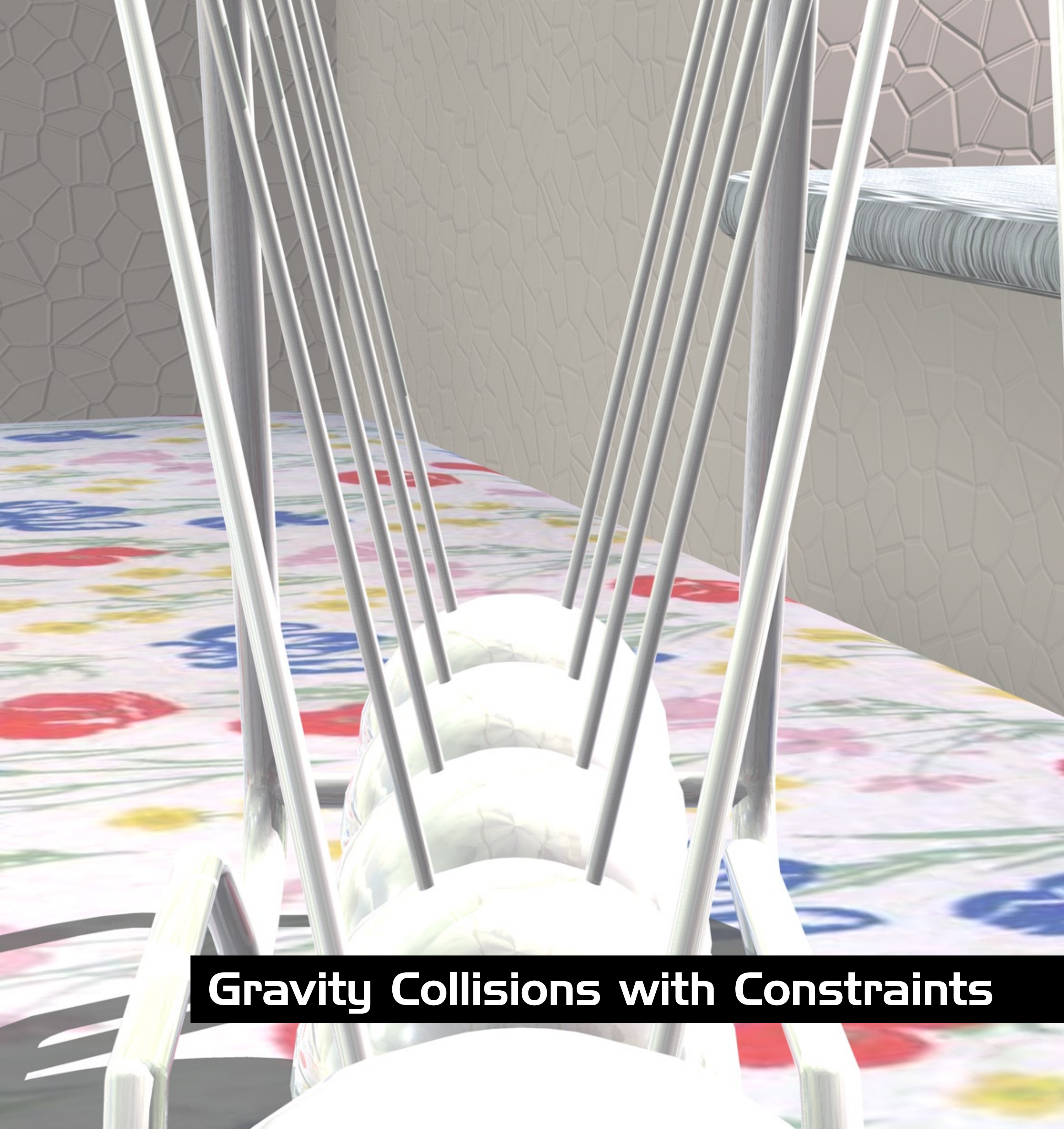
▶ **Click Play to see the bouncy character spring to life.**

You might notice that at times the feet pass through each other. If you turn to the tutorial on Gravity Collisions you can learn how to prevent this from happening. (The finished animation in the tutorials folder, ‘rbs2final.c4d’, uses this technique.)

Summary

While following this tutorial you may have noticed the Plastic and Break tabs inside the Rigid Springs dialog. We did not cover these here as they were not needed to create the movements we were after. You can of course try enabling the Plastic and Break sections if you wish. These will ruin the springs if you stretch them too much and if pulled on too hard, actually snapping the spring so it no longer has any effect on the dynamics.

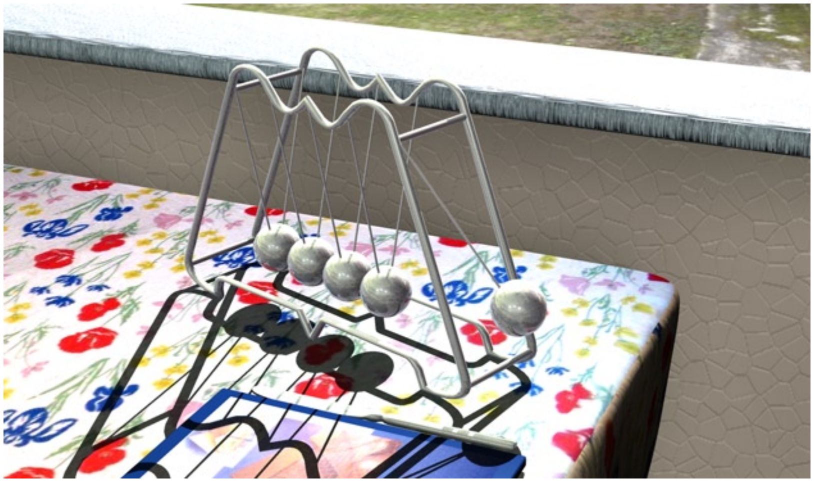
When we get to the soft body tutorials we will see that they have very similar spring dialogs. This is because each point on a soft body is actually connected with a spring in order to give it a fluid motion and to allow it to stretch.



Gravity Collisions with Constraints

Gravity Collisions with Constraints

In many circumstances we may need to limit the motion of objects because they are attached to other objects; for this we use constraints.

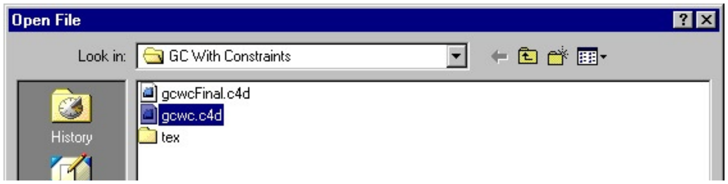


During dynamics simulations all objects are treated as individuals and the hierarchy of objects is ignored if they have a rigid or soft body tag. This raises the question of how we link objects together and still enable them to interact through the dynamics engine.

We could link two objects using a spring, and in some cases this is a valid choice, but it is also subject to the limits of the solver on the values for the forces. Using a spring which has a very high stiffness can lead to overflowing values which can eventually break the dynamics. Using constraints doesn't suffer this problem.

▶ **Select File > Open. Navigate to the GC With Constraints tutorial folder on your Documentation CD and open the file named 'gcwc.c4d'.**

Open the file to begin the tutorial.
The Tutorials folder is in the Dynamics module folder. Each tutorial has its own folder within the main Tutorials folder.



GC With Constraints

gcwcFinal.c4d
gcwc.c4d
tex

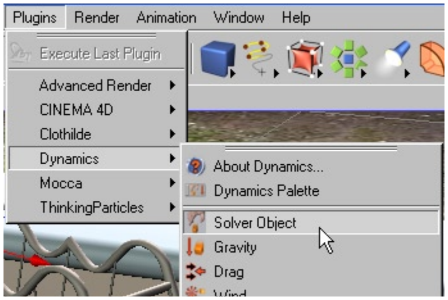
The new scene is now available in the view, this is a Newton's cradle. The idea behind this executive toy is that in a perfect Newton's cradle the momentum is transferred between the two end balls without the middle balls seeming to move. In our animation we shall aim for a similar appearance by using simplified gravity collisions. We will keep it deliberately simple so that we can see the collisions and constraints in action.

▶ **Ensure that Animation > Frame Rate > All Frames is enabled.**

We need to be able to see every frame; this enables us to check that every frame is how we want it to look, plus it prevents the dynamics from calculating many frames at once, which can be slow on some complex scenes. When working with dynamics we should make it a habit to ensure that All Frames in enabled.

▶ **Select Plugins > Dynamics > Solver Object.**

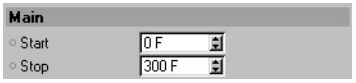
Solver objects determine the accuracy of the simulation.



A Solver object will appear in the Object manager; this object is where we will add the objects that we want to interact through dynamics and is necessary for any dynamics system to work.

▶ **On the Solver's Main tab set the Stop frame to 300.**

By default, the simulation stops too early for us. Extend it by adjusting the Stop frame.



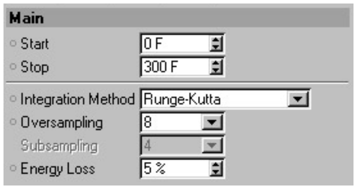
Main

Start	0 F
Stop	300 F

We want the animation to last the length of our project as defined in the project settings, so we set the stopping frame for the dynamics to the end frame on our timeline.

▶ **Set the Integration Method to Runge-Kutta, and the Oversampling to 8.**

When no soft bodies or real collisions are used, we can often use lower settings in the solver.



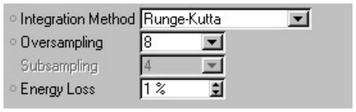
Main

Start	0 F
Stop	300 F
Integration Method	Runge-Kutta
Oversampling	8
Subsampling	4
Energy Loss	5 %

When the initial ball collides, the other balls will also collide in very quick succession. If we used a lower integration type of oversampling the collisions can become softer and may end up speeding up the movement rather than just passing it along.

► **Set the Energy Loss to 1%.**

We can make the Newton's cradle lose energy over time by specifying an Energy Loss amount.

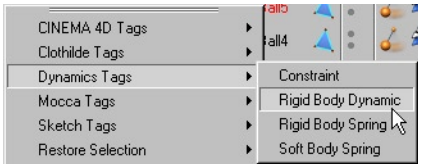

Integration Method: Runge-Kutta
Oversampling: 8
Subsampling: 4
Energy Loss: 1 %

To help control the momentum transfer during the dynamics and to aid in slowing the balls' collisions as would really happen we need a little energy loss. By using this option it is also possible to use a slightly lower oversampling as it aids in preventing the increasing velocities that can lead to the dynamics breaking.

Command-click on a Mac if you have only one mouse button.

► **In the Object manager, open the Cradle group and select the five balls (from Ball5 to Ball1). Right-click on one of the balls and select Dynamics Tags > Rigid Body Dynamic.**

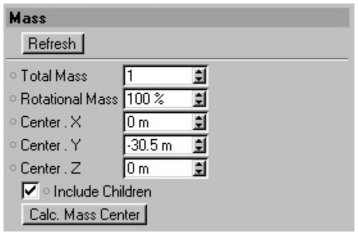
Rigid Body Dynamic tags enable Dynamics to take control of the objects' motion.



Each of our balls will need to be a solid object so that we may use the gravity collision method discussed in a previous tutorial.

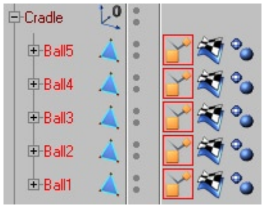
► **Ensure that all five Rigid Body Dynamic tags are selected. On the Mass tab, set the Center.Y to -30.5.**

The centre of mass needs to be moved downwards to the middle of the ball.


Mass
Refresh
Total Mass: 1
Rotational Mass: 100 %
Center . X: 0 m
Center . Y: -30.5 m
Center . Z: 0 m
☑ Include Children
Calc. Mass Center

The ball object actually includes the wires from which it will swing. We have positioned the origin for these objects at the top point about which they will swing, this is used later by the constraints. To position the centre of mass at the correct point, which is at the centre of each ball, we need to adjust it using the custom offset from the origin of object.

Identical tags for the five balls.

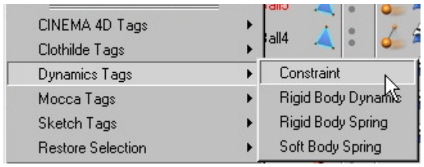


As each ball is identical, there is no reason not to give them all the same centre of mass.

Command-click on a Mac if you have only one mouse button.

► **Ensure that all five balls are selected. Right-click on one of the balls then select Dynamics Tags > Constraint.**

The constraint tag will restrict the movement of an object around its origin.

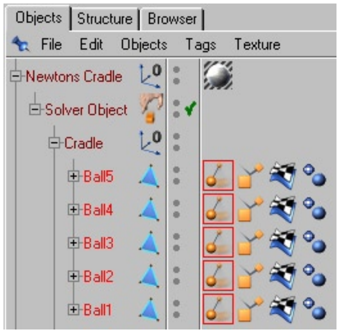


To pin our cradle balls to the surrounding frame we will need to constrain them to a point. We prevent them from moving by fixing each x, y and z coordinate of the object's origin to a point about which we want it to swing.

We need each ball to be constrained so that when they collide they are forced to swing about the fixed point of their origin.

► **Ensure that all five Constraint tags are selected. In the Attribute manager, click the Use Current button.**

Constraint positions are calculated relative to the parent. A 0,0,0 offset places them in the same location.



To constrain an object we need to give the dynamics a coordinate that is relative to its parent to which each coordinate can be fixed. This is an important point to remember, the actual point is always relative to the parent, and this will be where the object's origin will become fixed. We must also remember to correct the centre of mass from the origin should we move the origin away from where the centre of mass should be.

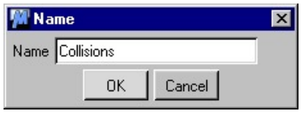
▶ **Drag the Cradle group into the Solver object.**

Now that we have prepared each of our balls, we can place them into the solver. When this happens the dynamics will initialise each object automatically and fix its initial position. If you later wish to move any of the objects you must turn off the solver and then move the object, followed by the Initialize All Objects or Initialize Object option in the Plugins > Dynamics menu, then turn the solver on again.

▶ **Select Plugins > Dynamics > Gravity and drag the Gravity object into the solver.**

▶ **Double-click on the Gravity object's name, rename it Collisions, click OK.**

We are renaming the Gravity object to reflect its purpose.

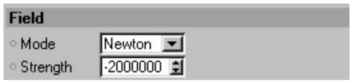


Name: Collisions

For our balls to collide we'll use a Gravity object to speed up the processing needed for the animation. For collisions that don't appear directly in front of the camera and don't need much detail, using Gravity can make a big saving in processing time.

▶ **On the Field tab, set the Strength to -2000000 and the Mode to Newton.**

Huge numbers will give the effect of a collision.

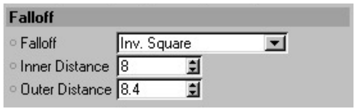


Mode: Newton
Strength: -2000000

Setting a very large negative strength for the gravity will make it appear as though nothing can enter the gravity field; anything that comes near it will bounce away immediately. The disadvantage of using this technique is that when the values for the Gravity are so high we must be careful to prevent the scene from exploding.

▶ **Click on the Falloff tab, set the Falloff to Inv. Square, the Inner Distance to 8 and the Outer Distance to 8.4.**

Lower solver settings can be used if we make use of a falloff value; this gives the objects a chance to be repelled.



Falloff: Inv. Square
Inner Distance: 8
Outer Distance: 8.4

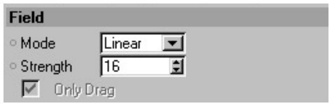
To compensate for the extremely large gravity strength we will use a falloff that will create a very thin shell of gravity around the surface of each ball. This will make the collision very strong only over a very small region, helping to make the collision appear more realistic.

- **Select Plugins > Dynamics > Gravity and drag the Gravity object into the solver.**
- **On the Field tab, set the Strength to 6.**

The balls will appear to swing more freely if there is a force to pull them back down again. As the gravity tries to pull, the constraint will hold the origin of the object at its fixed position. The only motion we didn't constrain was the angle, allowing the ball to pivot and swing freely.

- **Select Plugins > Dynamics > Drag and drag the Drag object into the solver.**
- **On the Drag's Field tab, set the Strength to 16.**

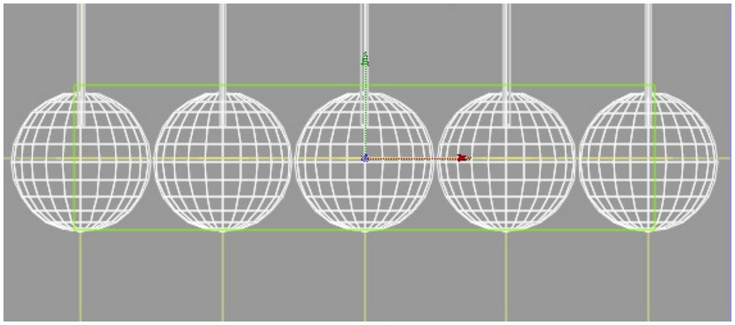
Small areas of drag can be used to calm down the simulation.


Field
Mode: Linear
Strength: 16
☑ Only Drag

To help control our extremely large gravity we are going to stop any jitter and exploding motion by forcing the balls in the centre to remain virtually still. This will make our cradle appear more like a real perfect one.

- **Click on the Shape tab and set the Shape to Cube.**
- **In the viewport, position the Drag object (the green outlined cube) at the centre ball, then scale and rotate the cube so that the drag is completely around the three middle balls and the edges are just covering the centres of mass of the two outer balls.**

Place the drag field into the position where we want to slow down movement.



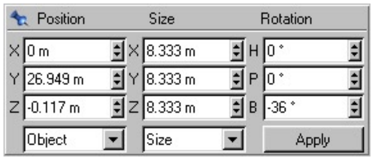
To aid the motion of our outer balls we set the drag so that, if they should move too far towards the inner balls, they will be slowed greatly, allowing the inner balls' gravity to force them back outwards. This will give a slight bump as the outer balls crash down, making it appear more realistic.

If you're feeling brave, try changing the size of the Drag object and see how this affects the movement of the balls.

▶ **Check the time slider to ensure that the current frame is 0, then click on the small green tick next to the Solver.**

Before adjusting the position or rotation for objects you need to disable the solver, otherwise it has control over the objects and will prevent you from interacting with them in the viewport.

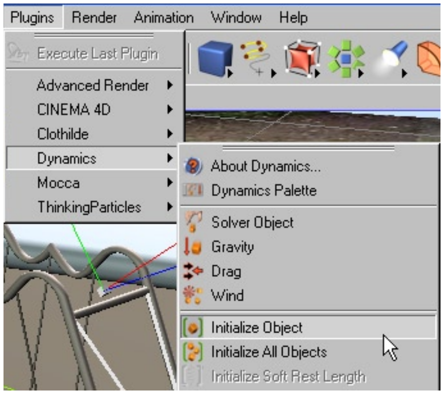
▶ **In the Object manager, select the Ball1 object then in the Coordinate manager set the B rotation to -36 and click Apply.**


Position		Size		Rotation	
X	0 m	X	8.333 m	H	0 °
Y	26.949 m	Y	8.333 m	P	0 °
Z	-0.117 m	Z	8.333 m	B	-36 °
	Object		Size		Apply

Pull back the first ball into position, ready to be released.

This pulls back the ball ready to drop it. Once we have a simple cradle working we can try changing the angle; we may find that at large angles we need to increase the strength of the gravity or the drag.

▶ **Ensure that the Ball1 object is selected in the Object manager, then select Plugins > Dynamics > Initialize Object.**



After moving an object in a solver we must initialise either the scene or the object to retain the current positions.

► **Click the red cross next to the solver to turn it back on.**

Having moved our object to a new position we need to tell the dynamics that this is our starting position.

► **Click Play and then click Stop when you are finished.**

The initial ball that we rotated swings and collides with the second ball. Each ball collides until the final ball is forced to swing again around is pivot. By adjusting the strength of the gravity we can speed up the swing of the outer balls.

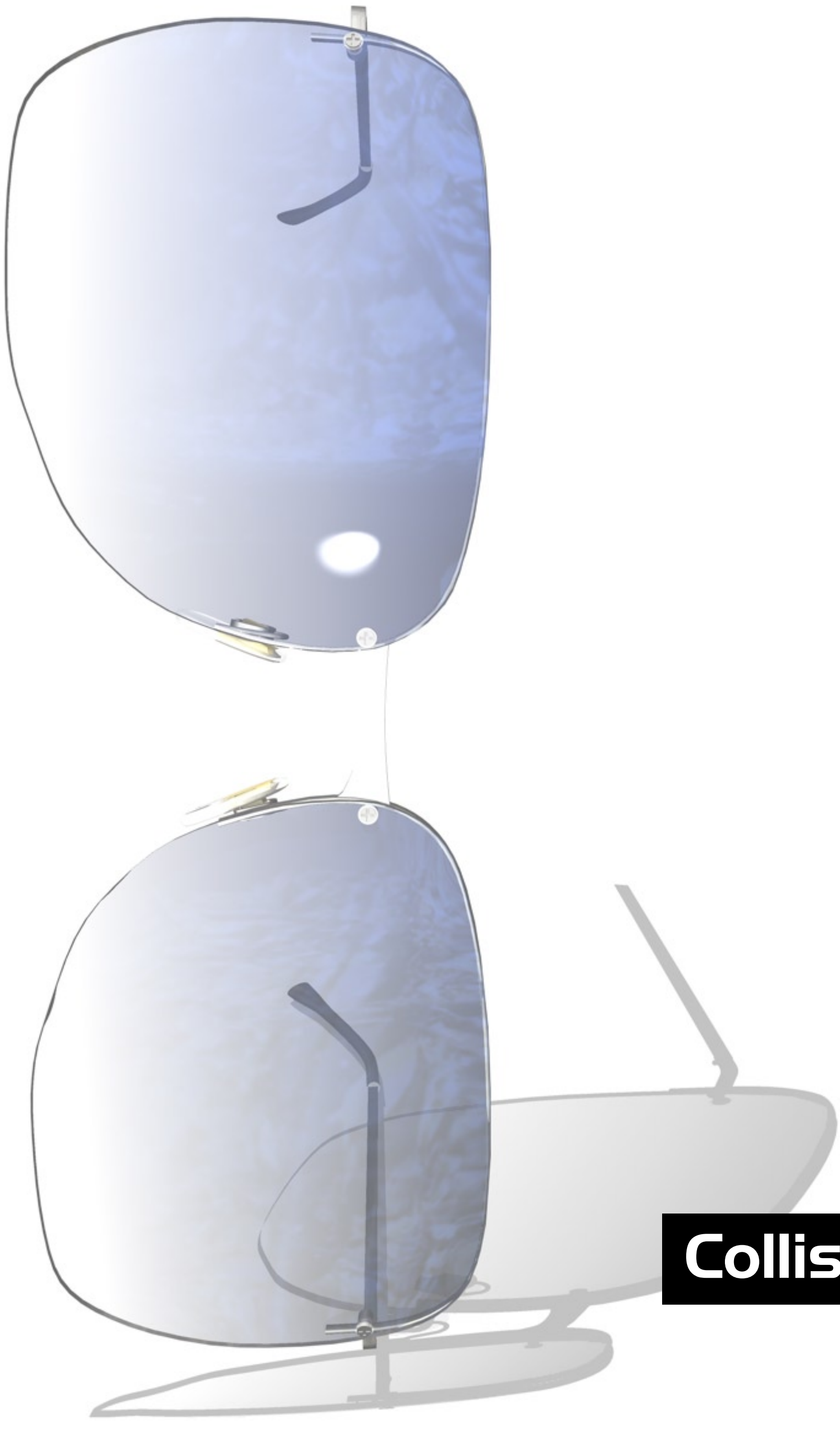
Summary

By constraining motion we can link objects together, or make them appear to be connected, such as the balls and frame of the cradle. The use of gravity for the collisions gives us a virtually realistic appearing animation at much lower processing power.

Unlike the pool table example, here the balls would not rotate and so this could be used under closer inspection.

The main problems with gravity collisions are a tendency to suddenly gain speed during the interaction; we have shown how to cope with this by careful positioning of drag to remove this additional motion.

Taking this scene a step further, we could introduce more balls, or make two balls swing to start with. Although making alterations such as these will require some modifications to the scene, the time saved in processing the animation over real collisions can be a worthwhile investment.



Collision Detection

Collision Detection

While gravity based collisions can be useful, when objects need realism in their interactions, nothing beats the full and proper detection of collisions.

When using collisions in our animation we can break up the detail into various levels. The less detail we need then the more we can use simple gravity repulsion to create the illusion of collision.

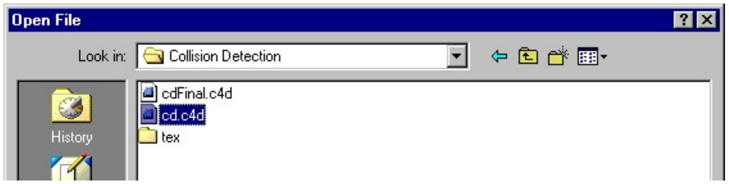
The next level up from faked collisions is to use very simple proxy objects with full collision detection. By using these we can vary the detail needed in our collisions from very simple geometry to a polygon reduced duplicate of our real geometry. If we have a close up and need perfect behaviour, we can use a more detailed proxy, or our original object itself.

The advantage of simplified collisions through gravity or proxy objects is to give a speed boost to the simulation. Full collision detection with all our real objects will depend fully on their complexity, and in some cases may not even work due to the objects being over complex for the collision detection system to handle; the only solution in such a situation is to find a proxy object that closely matches the original, but that is also simple enough to use.

We're going to take an intricately modelled pair of sunglasses and drop them on to a table top; we'll use a simple proxy object to help us.

▶ **Select File > Open. Navigate to the Collision Detection tutorial folder on your Documentation CD and open the file named 'cd.c4d'.**

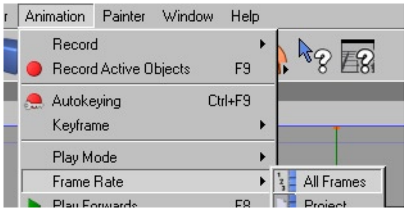
Open the cd.c4d file to be presented with a pair of glasses which we can drop.
The Tutorials folder is in the Dynamics module folder. Each tutorial has its own folder within the main Tutorials folder.



The scene objects are now available in the Object manager. We have already made a simple proxy object for you, a cube, which has been hidden in the render and viewport.

▶ **Ensure that Animation > Frame Rate > All Frames is enabled.**

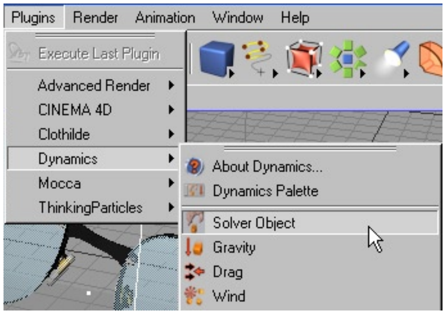
Display every single frame to make sure Dynamics does not miss out any frames needed for the calculation.



When using the dynamics we need to be able to see every frame, this enables us to check that every frame is how we want it to look, plus prevents the dynamics from calculating many frames at once, which can be slow on some complex scenes.

▶ **Select Plugins > Dynamics > Solver Object.**

Solver objects are required for Dynamics to know which objects it should be working on.



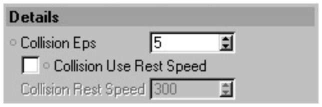
A Solver object will appear in the Object manager. This is where we will add the objects that we want to interact through dynamics to give us our collision.

▶ **On the Solver object's Main tab, set the Integration Method to Midpoint and Oversampling to 8.**

Generally collisions on their own will work with a less accurate integration method and lower oversampling, the type of dynamics that need high oversampling and accuracy are soft bodies.

▶ **Click the Details tab and set the Collision Eps to 5.**

We need to alter some of the solver settings, such as the Eps, in order to suit the simulation.

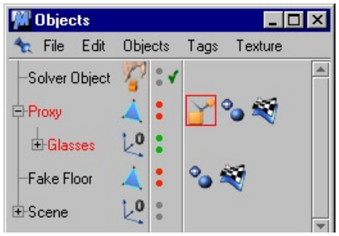

Details
Collision Eps 5
Collision Use Rest Speed
Collision Rest Speed 300

The Eps setting (Epsilon) determines how close an object can get to another before it collides. By reducing this setting we can give the effect of the object deforming slightly by allowing colliding objects to penetrate each other slightly.

Command-click on a Mac if you have only one mouse button.

▶ **Drag the Glasses object into the Proxy object then, making sure you have the Proxy object selected, right-click and select Dynamics Tags > Rigid Body Dynamic.**

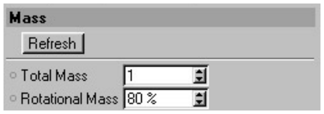
Use proxy objects as stand-ins if the geometry of the actual objects is too complex.



We want the proxy object to be our rigid body; the glasses will follow the motion of this proxy by sitting in the proxy object's local coordinates.

▶ **On the Mass tab set the Rotational Mass to 80%.**

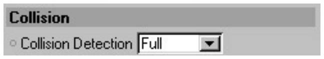
To make our glasses appear lighter we will reduce the rotational mass; they can now rotate more upon landing.


Mass
Refresh
Total Mass 1
Rotational Mass 80 %

Our sunglasses are made from a light material and should rotate easily. They also have a heavy front so we want them to drop on the table and rock slightly, plus rotate a little from the collision. Often collisions need their rotational mass changing, real objects rotate differently depending on the density of the materials from which they are made.

► **Click the Collision tab and set Collision Detection to Full.**

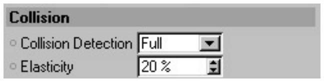
Full detection is required for the glasses to land convincingly.


Collision
Collision Detection: Full

Our proxy object is already simple, so we don't want any of the simplified collision detection methods, we need the full detection on our own simple geometry.

► **Set the Elasticity to 20%.**

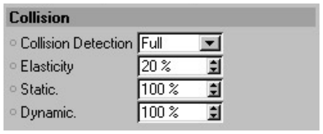
We need the glasses to bounce slightly, reducing the elasticity to 20% should be fine.


Collision
Collision Detection: Full
Elasticity: 20 %

As our sunglasses fall on to the table, they will not bounce very much. The structure of the sunglasses is flexible and the energy will be mostly lost from the collision. Reduced Elasticity will prevent the sunglasses from bouncing.

► **Set the Static and Dynamic coefficients to 100%.**

Without friction coefficients the glasses will continue to slide after they have hit the ground.


Collision
Collision Detection: Full
Elasticity: 20 %
Static: 100 %
Dynamic: 100 %

When our sunglasses are on the surface of the table we don't want them moving around; friction will keep them still and stop them sliding or rotating. Friction is controlled by the static and dynamic coefficient values. Here we are using the dynamic coefficient to slow down the sunglasses while they are moving and the static coefficient to keep them in place once they have come to a stop.

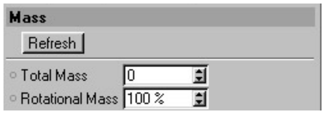
Command-click on a Mac if you have only one mouse button.

► **In the Object manager, select the Fake Floor object, right-click and select Dynamics Tags > Rigid Body Dynamic.**

We want our sunglasses to appear to land on a solid surface. In a similar way to that in which we used a proxy object for the sunglasses, we are going to use a single plane as a proxy object for the collision.

► **On the Mass tab, set the Total Mass to 0.**

To create a rigid and unmovable floor in our scene, we set its mass to 0.

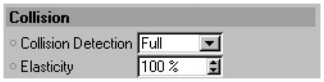

Mass

Total Mass: 0
Rotational Mass: 100 %

We don't want our plane to move when the sunglasses land, or for the gravity object to move our Fake Floor object; setting its mass to zero will prevent dynamics from having any effect on it.

▶ **Click on the Collision tab and set Collision Detection to Full.**

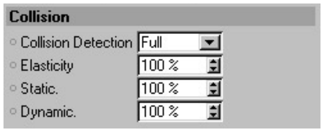
Full collision detection will improve the accuracy of the simulation.


Collision
Collision Detection: Full
Elasticity: 100 %

As with our proxy object, we have already simplified the geometry so we can use full collision detection.

▶ **Set the Static and Dynamic coefficients to 100%.**

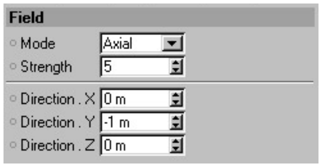
The floor also needs the friction coefficients enabled for it to grip the glasses when they land.


Collision
Collision Detection: Full
Elasticity: 100 %
Static.: 100 %
Dynamic.: 100 %

We want our floor to keep grip of the sunglasses, to stop them sliding around, so we use the static and dynamic coefficients to add friction.

▶ **Select Plugins > Dynamics > Gravity and on the Field tab set the Strength to 5.**

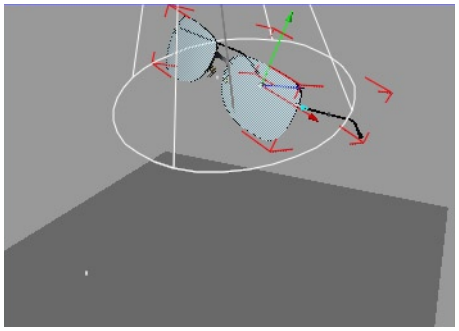
The downward pull of gravity will be a common requirement in many simulations.


Field
Mode: Axial
Strength: 5
Direction . X: 0 m
Direction . Y: -1 m
Direction . Z: 0 m

We want our sunglasses to fall quickly on to the floor; to make it appear realistic it should take much less than a second for them to fall that distance. When creating scenes such as this, it is worth checking that we have got roughly the right timing for falls and collision; if things fall or move too slowly or too quickly, the animation won’t look quite right. Set up a simple real life situation or, if you’re really brave, try calculating the times with mathematics.

▸ **In the viewport, move and rotate the proxy object so that it is above the floor at a slight angle.**

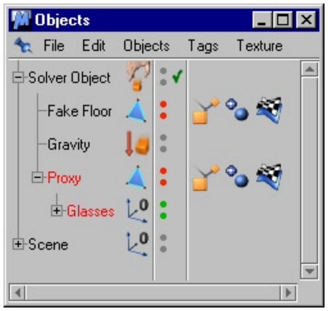
Reposition the glasses above the ground so that they have a distance to fall.



Now we have our scene ready, we want to drop the sunglasses. Moving them up and rotating them slightly will give a more interesting bounce. The proxy object has been designed to show overall collision of the glasses, so rotating the sunglasses so that they land lens-first will not give a realistic looking collision; for this we would have to add a curve to the front of the proxy.

▸ **Drop the Proxy object, Fake Floor and Gravity into the Solver object.**

Place the three objects into the solver so that Dynamics can apply physical movements to them.



Now we have prepared each object, we need to put them into the solver so that Dynamics can take over and make our animation come to life.

▸ **Click Play and then click Stop when you are finished.**

The falling sunglasses show a simple way of using proxy objects. We have ignored some areas in this, such as the arms of the glasses, but for medium detail collisions that are not in the full view of the camera, or in a distant part of your scene, such simplification helps to greatly speed up the process of building the scene, plus animating it.

You may have noticed that the sunglasses are still moving around long after the collision. These small movements are to be expected when we are working with dynamics simulations. One way to halt the sunglasses would be to turn off the dynamics simulation at just the right moment using the solver's Stop parameter on the Main tab.

Summary

As we have seen, we do not need to use the full geometry of the original object for collision detection. Our model geometry will often be far too complex to be used like this and will take a long time to render. By using proxy objects we can create much simpler stand-in objects to which we can apply collision detection.

Depending on your computer system, during this tutorial you may have noticed that the playback speed in the viewport was not very smooth. If so, you may wish to make use of the Render > Make Preview command which will enable you to create a much smoother playback of the simulation.

Gravity Collisions with Soft Bodies

Gravity Collisions with Soft Bodies

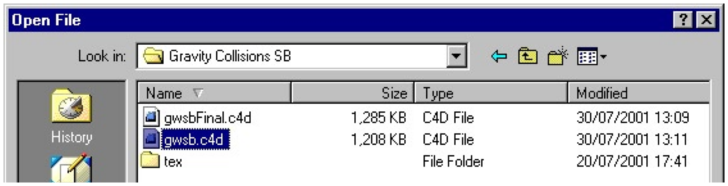
We can interact with soft body masses by using gravity in a similar way to that in which we created simple collisions with rigid bodies.

It is possible to use soft bodies to simulate a rippling surface in order to create the illusion of water. A liquid surface has a tension that makes it act in a similar way to the soft bodies in Dynamics. By using gravity to affect the soft body it is possible to disturb a surface in such a way that it gives the impression of objects interacting with the water.

In this tutorial we are going to extend the Motion With Drag tutorial by causing the surface of the beer to ripple when the coin drops into it.

We will see that by adding some soft body springs to the Beer object we can use gravity and drag to simulate a pretty realistic liquid, rippling surface.

► **Select File > Open. Navigate to the 'GC With Soft Bodies' tutorial folder on your Documentation CD and open the file named 'gwsb.c4d'.**



Name	Size	Type	Modified
gwsbFinal.c4d	1,285 KB	C4D File	30/07/2001 13:09
gwsb.c4d	1,208 KB	C4D File	30/07/2001 13:11
tex		File Folder	20/07/2001 17:41

Open the file to begin the tutorial.
The Tutorials folder is in the Dynamics module folder. Each tutorial has its own folder within the main Tutorials folder.

The scene objects are now available in the Object manager. As in the Motion With Drag tutorial, we want to take this one step further and make the coin actually move the surface of the beer.

- **Ensure that Animation > Frame Rate > All Frames is enabled.**

  When using dynamics we need to be able to see every frame; this enables us to check that every frame is how we want it to look, plus it prevents the dynamics from calculating many frames at once, which can be slow on some complex scenes.

- **Disable the Beer Solver object by clicking on its green tick.**

  To allow us to start moving objects within the solver we need to disable it. While a solver is enabled it will override anything we try to do, such as moving objects.

- **Click on the Solver object's icon and on the Main tab set the Integration Method to Adaptive, Oversampling to 16 and Subsampling to 16.**

  By using Adaptive we can specify a subsampling value which will be used to further divide the frames when it becomes necessary.

  Although there is a Soft Body integration method, we won't use it here because it is geared towards simulating cloth-like motion.

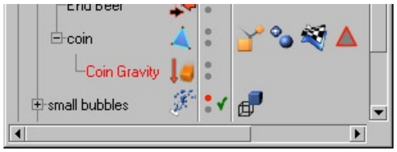
- **Leave the Energy Loss set to 0.**

  There is no need for us to remove energy from the system because we already have several drag objects set up from the Motion With Drag tutorial.

- **Select Plugins > Dynamics > Gravity. In the Object manager, double-click on the name of the Gravity object, change its name to Coin Gravity and click OK.**

- **Drag the Coin Gravity object into the Coin object to make it a child of Coin.**

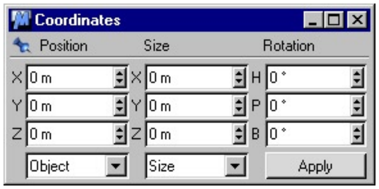
By making the gravity field a child of the coin, it will move wherever the coin goes.



To enable the coin to interact with the beer we will use a Gravity object to pull at the surface of the beer as the coin falls into it.

► **Ensure you have the Coin Gravity object selected, then in the Coordinate manager set the X, Y and Z positions and the H, P and B angles to 0 and click Apply.**

Setting all of the values to zero will cause the object to take up the same position as its parent, in this case the coin.


Coordinates

Position		Size		Rotation	
X	0 m	X	0 m	H	0 °
Y	0 m	Y	0 m	P	0 °
Z	0 m	Z	0 m	B	0 °
Object		Size		Apply	

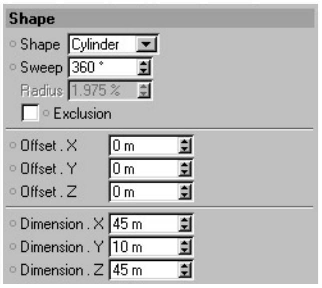
So that we can make a gravity field around the coin, we are changing the origin of the Coin Gravity to be the same as that of the Coin.

► **In the Object manager, click on the Coin Gravity icon.**

► **On the Field tab, set Strength to 30, Direction.Z to -1 and the other Direction values to 0.**

► **Click the Shape tab and set the Shape to Cylinder, Dimension.X and Z to 45, and Dimension.Y to 10.**

Similar or identically shaped force fields can be used in place of full collision detection.

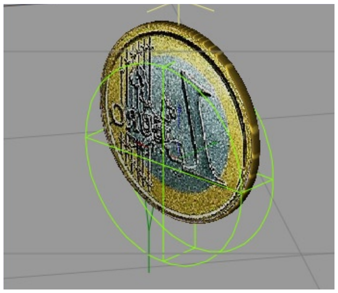

Shape

Shape	Cylinder
Sweep	360 °
Radius	1.975 %
Exclusion	
Offset . X	0 m
Offset . Y	0 m
Offset . Z	0 m
Dimension . X	45 m
Dimension . Y	10 m
Dimension . Z	45 m

We'll use a shape and size for the gravity that is approximately that of the coin; this will help to pull the surface of the beer in a similar way to that which the coin would as it collides with the beer.

▶ **Ensure you have Coin Gravity selected and, in the viewport, move the object down the world Y axis so that the bottom of the gravity cylinder is slightly below the coin.**

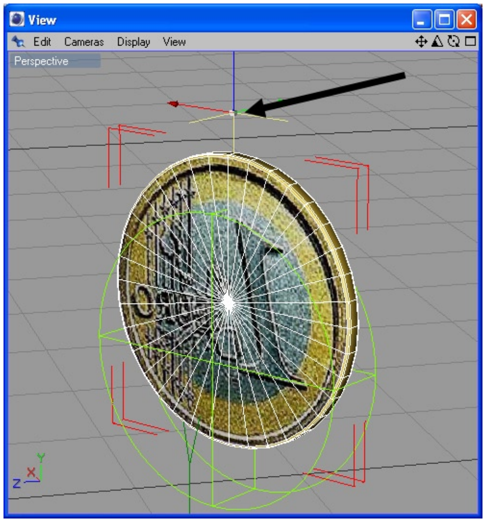
The surface of the liquid needs a fraction of a second to accelerate, moving the gravity will give it the time it needs.



The gravity collision will be soft, that is it will not start moving immediately, so we want the surface to start moving just as the geometry of the coin reaches it. By positioning the gravity far enough below the coin we should achieve this.

▶ **Ensure you have the Coin object selected, then select the Object Axis Tool and make sure the origin is outside of the Coin Gravity and just above the coin.**

Force fields affect an object only if its axis is within the field. We can move the origin away to deliberately exclude its influence.



In this case, we do not want the coin itself to interact with its own gravity. By moving the coin's origin it will still interact with the local gravity but will be outside the influence of the Coin Gravity object.

▶ **Select Plugins > Dynamics > Initialize All Objects.**

The scene (or individual objects) must be initialised before re-enabling the Solver object. If we enabled the solver without doing this then all the movements we made would be lost.

▶ **Enable the Solver object by clicking on its red cross.**

With the Solver object turned off, Dynamics will not calculate anything inside it. We have to enable the solver before we proceed otherwise no springs will be shown, nor will they affect the project as they should.

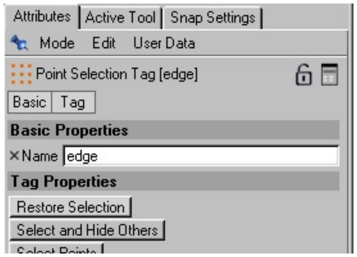
Command-click on a Mac if you have only one mouse button.

▶ **In the Object manager, right-click on the Beer Geometry object and select Dynamics Tags > Soft Body Spring and close the dialog (we'll add the springs later).**

To create our beer surface we need to add a soft body tag so that we can add the springs for the geometry.

▶ **Click on the Edge point selection tag for the Beer Geometry object. In the Attribute manager click Restore Selection, then select the Points tool.**

To stop the surface from flying away we can effectively nail down the edge of the beer.



You should be able to see that the points around the surface of the beer are selected; we need these points so that we can define the edge of our surface. (If you can't see the points it probably means that you haven't selected the Points tool.)

▶ **Select Plugins > Dynamics > Set Soft Mass, set the Mass to 0 and click OK.**

To stop the edge of our surface moving we need to ensure that its points have a mass of zero; this stops the dynamics from controlling the motion and can be used as a boundary to prevent movement.

▶ **Double-click on the Surface point selection tag for the Beer Geometry object.**

You can now see that the whole surface is selected; these are the points to which we want to add springs.

► **Select Plugins > Dynamics > Add Soft Springs and click OK.**

For the surface use the default settings and structural springs; these springs link all points along the polygons of the surface and will hold the points together.

► **Click Play and then click Stop when you are finished.**

The coin should fall into the beer; the surface should be pulled down and then should gently spring back up and ripple. Although this is not a true fluid, it can be adequately used to give a fluid-like behaviour.

Summary

We have learned from this tutorial that soft bodies can be used for more than just cloth — any flexible surface or object can be created and interacted with. The motion of these types of objects is usually difficult to create by keyframing, and by using dynamics we can drastically shorten the time spent getting the motion to appear correct.

We have seen how to use gravity shapes to affect only certain areas of our scene, and how to move the object axis to prevent interactions with gravity objects that use a child to make them follow the rigid bodies movement.

We have also seen how to set the soft masses using the point selection tools, and how to add springs to only selected points.

By using these techniques we can create many complex types of materials from simple actions and leave the hard work to Dynamics.

Gravity Collisions with Plastic Soft Bodies

Gravity Collisions with Plastic Soft Bodies

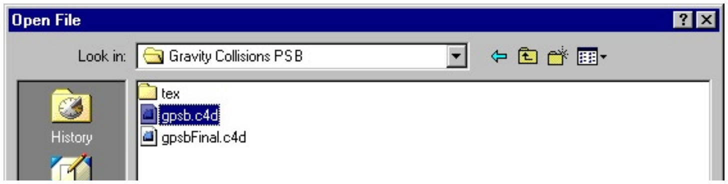
Sometimes we may want the surface of a soft body to retain a shape once deformed. We can achieve this with the plastic springs option.

MAXON
computer

We can use the plastic nature of soft body springs to create the impression of a soft body that will remain deformed. In the real world a spring that is stretched too far will start to behave more like plastic, remaining deformed at its stretched length. Soft body springs can be made to exhibit this behaviour, so that once they are stretched they will remain deformed, while still giving some resistance to the motion via the stiffness of the springs.

By using gravity we can pull on the soft masses to deform the soft body while using the plastic option to retain the deformation of the geometry. We are going to use this technique to create a sugar cube dropping into some thick creamy froth that will deform as the cube enters, but will not return to its original shape.

▶ **Select File > Open. Navigate to the 'Gravity Collisions PSB' tutorial folder on your Documentation CD and open the file named 'gpsb.c4d'.**



Open the gpsb.c4d file from the tutorials folder, this will be our starting scene.
The Tutorials folder is in the Dynamics module folder. Each tutorial in this manual has its own folder within the main Tutorials folder.

The scene objects are now available in the Object manager. The main objects we are interested in are the Sugar Cube and the Froth.

▸ **Ensure that Animation > Frame Rate > All Frames is enabled.**

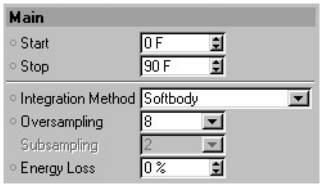
When using dynamics we need to be able to see every frame; this enables us to check that every frame is how we want it to look, plus it prevents the dynamics from calculating many frames at once, which can be slow on some complex scenes. When working with dynamics we should make it a habit to ensure that All Frames is enabled.

▸ **Select Plugins > Dynamics > Solver Object.**

A Solver object will appear in the Object manager; this object is where we will add the objects that we want to interact through dynamics.

▸ **On the Main tab, set the Integration Method to Softbody, Oversampling to 8 and Energy Loss to 0.**

Use the Softbody integration method.



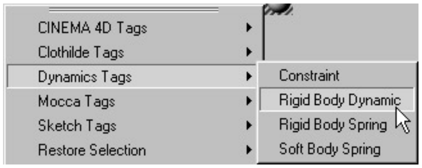
Main
Start 0 F
Stop 90 F
Integration Method Softbody
Oversampling 8
Subsampling 2
Energy Loss 0 %

The Softbody integration method is ideal here because it provides for extremely fast soft body calculations. An Oversampling value of 8 is as low as we can go before the simulation becomes unstable.

Command-click on a Mac if you have only one mouse button.

▸ **In the Object manager, right-click on the Sugar Cube object, select Dynamics Tags > Rigid Body Dynamic.**

The sugar cube will be the only rigid body object in this simulation.



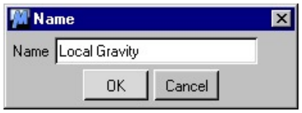
We need to make the Sugar Cube a solid object (i.e. a rigid body) so that we can use a Gravity object to make it fall into the mug. Later we will also need to adjust the centre of mass for the Sugar Cube by adjusting its origin.

▸ **Drag the Sugar Cube object into the solver.**

To enable the dynamics to take control of the sugar cube falling we need it to be a child of the Solver object; this is where the dynamics are calculated and all objects within it that have a dynamics tag can interact with the dynamics.

▸ **Select Plugins > Dynamics > Gravity, then double-click on the Gravity name in the Object manager and name it Local Gravity.**

We may need more than one Gravity object, it is a good idea to name them while we remember what they do.



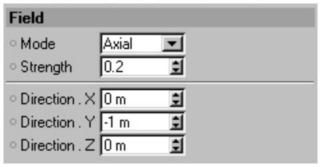
Name: Local Gravity

To give the sugar cube the movement that will make it appear to fall, we need a Gravity object; this will apply a force at the sugar cube's centre of mass causing it to accelerate in the direction of the axial gravity field.

▸ **Drag Local Gravity into the Solver object.**

▸ **On the Local Gravity's Field tab, set the Strength to 0.2.**

Default values will rarely be adequate for our simulations; be prepared to adjust them.

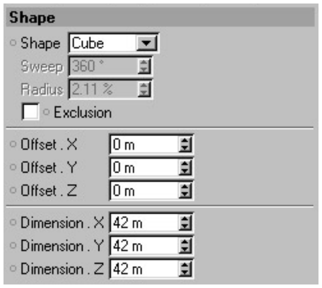


Mode: Axial
Strength: 0.2
Direction . X: 0 m
Direction . Y: -1 m
Direction . Z: 0 m

We need the sugar cube to accelerate for just a short distance; the remaining motion will be hidden within the mug.

▸ **Click the Shape tab, set Shape to Cube and Dimension.X, Y and Z to 42.**

Forces do not have to be everywhere. Here we are restricting the gravitational influence to a particular shape.



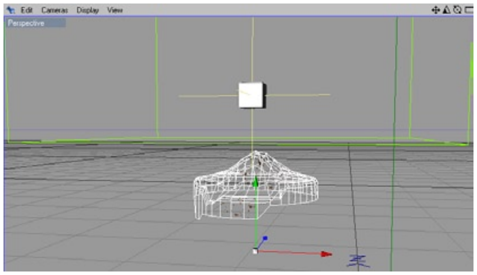
Shape: Cube
Sweep: 360 °
Radius: 2.11 %
Exclusion
Offset . X: 0 m
Offset . Y: 0 m
Offset . Z: 0 m
Dimension . X: 42 m
Dimension . Y: 42 m
Dimension . Z: 42 m

We need only a simple cube shape for the gravity so that we can control exactly where the sugar cube is accelerated.

▸ **In the Object manager, select the Local Gravity object and select Functions > Transfer. Drag Mug Objects from the Object manager into the Transfer To box in the Attribute manager. Disable the Enable Scale option and click Apply.**

▶ **In the viewport, move the gravity cube up the Y axis so that the bottom of the gravity cube is just above the top of the froth in the mug.**

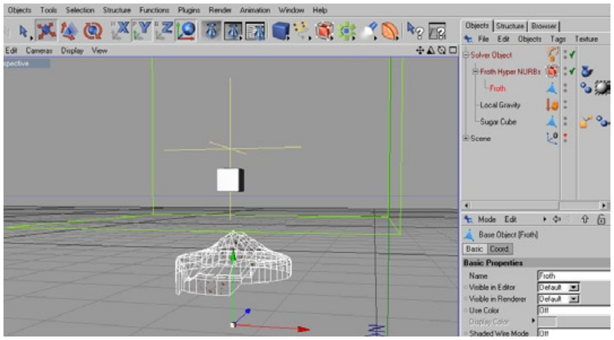
The gravity field will cause the sugar cube to fall, but not the froth.



While the sugar cube is in the air above the mug, we want it to accelerate. Although normally we would also have air resistance, in this case we can ignore it because the cube falls for only a short time before entering the mug.

▶ **Click Play and then click Stop when you are finished.**

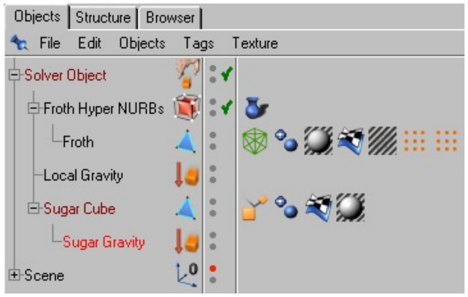
Feel free to play the simulation at any point during the tutorial. It will help us to understand the effect of each setting.



The sugar cube begins to fall gently until it leaves the gravity cube, at which point it then moves at the same speed downwards and through the bottom of the mug. This gives us our starting point for the sugar cube dropping into the mug.

▶ **Select Plugins > Dynamics > Gravity, double-click on the name of the Gravity object change it to Sugar Gravity and click OK. Drag the Sugar Gravity object into the Sugar Cube object.**

It's a good idea to invent a naming convention; this will help us when we return to projects.

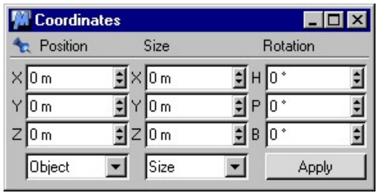


Solver Object
Froth Hyper NURBs
Froth
Local Gravity
Sugar Cube
Sugar Gravity
Scene

To enable the sugar cube to interact with the froth we'll use a Gravity object; this will pull at the surface of the froth as the sugar falls into the mug.

▶ **Ensure that the Sugar Gravity object is selected, then in the Coordinate manager set the X, Y and Z positions and the H, P, and B angles to 0 and click Apply.**

Replicating geometry using force fields can save much time compared with enabling full collision detection.

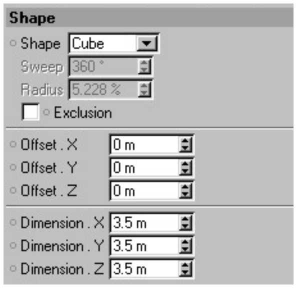


Position		Size		Rotation	
X	0 m	X	0 m	H	0 °
Y	0 m	Y	0 m	P	0 °
Z	0 m	Z	0 m	B	0 °
	Object		Size		

We want the origin of the Sugar Gravity object to be the same as that of the Sugar Cube object so that we can make a gravity field around it.

► **On the Sugar Gravity's Shape tab, set Shape to Cube and Dimension.X, Y and Z to 3.5. On the Field tab, set Strength to 20.**

This gravity field will represent the sugar cube, it should be scaled to similar proportions.

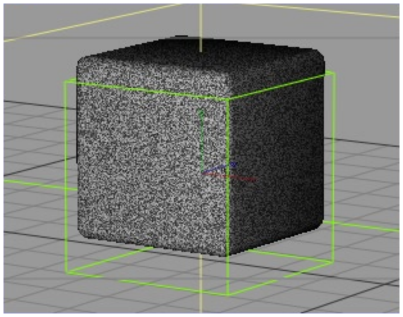

Shape

Shape	Cube
Sweep	360 °
Radius	5.228 %
☐ Exclusion	
Offset . X	0 m
Offset . Y	0 m
Offset . Z	0 m
Dimension . X	3.5 m
Dimension . Y	3.5 m
Dimension . Z	3.5 m

We'll use a shape and size that is approximately that of the sugar cube; this will help to pull the surface in a similar way to that in which the sugar cube would as it collides with the froth and pushes it downwards.

► **Ensure that the Sugar Gravity object is selected and, in the viewport, move the object down the Y axis so that the bottom of the gravity cube is slightly below the sugar.**

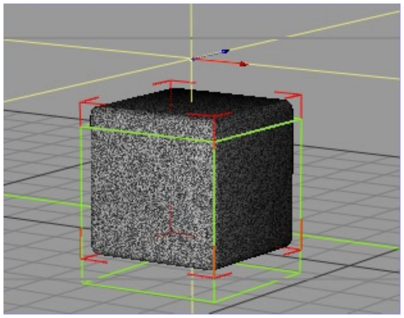
Reposition the cube of gravity so that it can influence the shape of the froth just before the cube impacts.



We want the surface of the froth to start moving noticeably just as the geometry of the sugar cube reaches it. By positioning the Sugar Gravity far enough below the sugar we can achieve this. You may find that you need to go back and move the gravity up or down slightly to achieve the movement you want.

▶ **Check if the origin of the Sugar Cube is just above the Sugar Cube. If it isn't, turn off the Solver object (click its green check mark), then select the Object Axis tool and move the origin along the Y axis to just above the Sugar Cube. Select Plugins > Dynamics > Initialize All Objects. Turn the Solver object back on (click its red cross).**

Dynamics uses the origin of objects to determine if objects are inside a field's area of influence.

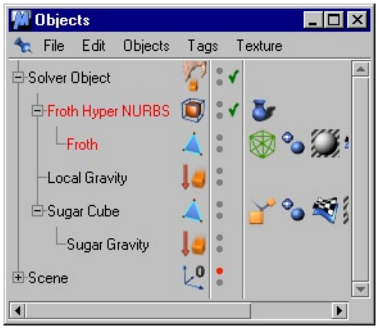


Here we do not want the sugar itself to interact with its own gravity, so by moving its origin it will still interact with the local gravity but is outside the influence of the sugar gravity.

Command-click on a Mac if you have only one mouse button.

▶ **In the Object manager, right-click on the Froth object and select Dynamics Tags > Soft Body Spring and close the dialog. Drag the Froth Hyper NURBS object into the solver.**

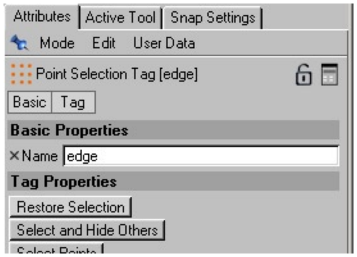
The froth is the only other geometry to be changed by Dynamics, via the Soft Body Spring tag.



To create our frothy surface we need to add a soft body tag so that we can create the springs for the geometry.

► **Click on the Froth object, click on its Edge point selection tag and in the Attribute manager click Restore Selection.**

Use as few springs as possible to keep the simulation running smoothly. Here we need to apply them only to the top on the froth.

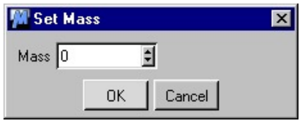

Attributes | Active Tool | Snap Settings
Mode Edit User Data
Point Selection Tag [edge]
Basic | Tag
Basic Properties
Name: edge
Tag Properties
Restore Selection
Select and Hide Others
Select Points

You should be able to see that the points around the surface of the froth are selected; we need these points so that we can define the edge of our surface.

► **Select the Points tool.**

► **Select Plugins > Dynamics > Set Soft Mass, set Mass to 0 and click OK.**

To hold the rest of the froth in place, simply set the mass of these points to zero. A mass of zero stops an object from moving.


Set Mass
Mass: 0
OK Cancel

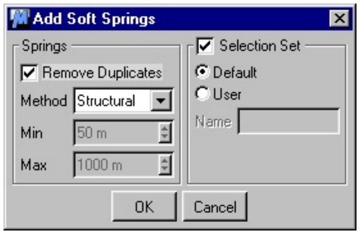
To stop the edge of our surface moving we need to make the points have a zero mass, this stops the dynamics from controlling the motion and can be used as a boundary to prevent movement.

► **Double-click on the Surface point selection.**

You can now see the whole surface is selected, these are the points to which we want to add springs.

► **Select Plugins > Dynamics > Add Soft Springs and click OK.**

Add soft springs to the object.


Add Soft Springs
Springs
[✓] Remove Duplicates
Method: Structural
Min: 50 m
Max: 1000 m
[✓] Selection Set
(●) Default
( ) User
Name:
OK Cancel

► **Double-click on the Soft Body Springs tag, set Damping to 1, click the Plastic tab and enable the Above option. Set Start At to 104%, Stiffness and Damping to 100%, Drag to 2%, then click Refresh and close the dialog.**

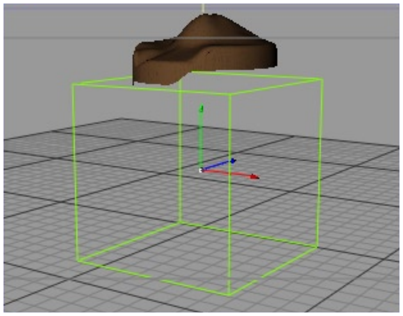
We want our froth-like surface to stretch easily, but then remain stretched without oscillating much. The Start Above option sets the soft body springs to start using the plastic behaviour once they have stretched above 104% of their rest lengths (their original lengths). We add a small amount of drag to the soft masses to help to slow any movement when the springs become plastic.

- **Select Plugins > Dynamics > Drag, then drag the Drag object into the solver.**

Lastly, we need to stop the sugar cube from falling through the mug. By using a drag cube inside the mug we can stop the sugar moving.

- **On the Field tab set Strength to 20.**
- **Click the Shape tab and set Shape to Cube and Dimension.X, Y and Z to 20.**
- **In the viewport, move the Drag object so that it sits below the froth as shown in the diagram below.**

Once an object is out of view, it is not important to spend time working on it. Just use a drag field to stop it.



This drag cube will stop the sugar cube once it has finished interacting with the frothy surface.

- **Click Play and then click Stop when you are finished.**

The sugar cube drops into the mug, pushing the frothy surface down. The froth remains deformed and the sugar cube stays in the mug.

Summary

When using soft bodies we may find that we need to increase the accuracy of our solver. Soft body springs perform many calculations — the more springs we have, the more likely we are to start having inaccuracies in the solver calculations due to the complex motion that can occur.

We can help to control this using the damping and drag values, but sometimes the only solution is to increase the oversampling and subsampling to prevent unwanted fluctuations in springs.

In this tutorial we have seen how to add soft body springs to selected points on a complex geometry. By carefully adjusting the spring values we can create many types of surface interactions. As with the liquid surface tutorial, we can see that the soft bodies in Dynamics can be used for more than just cloth.

The plastic nature shown in this tutorial lends itself to creating stiff, structured materials that keep their deformation. The nature of the plastic behaviour also increases the need to have a more accurate solver. The motion of these types of springs can be complicated because, as some of the springs start to turn plastic, the forces between the soft masses may start to become large, causing the dynamics to suffer.

Increasing the accuracy will help stop this, as illustrated in this tutorial. To see the behaviour that can result from badly tuned values, try decreasing the oversampling.

Soft Bodies with Wind

Soft Bodies with Wind

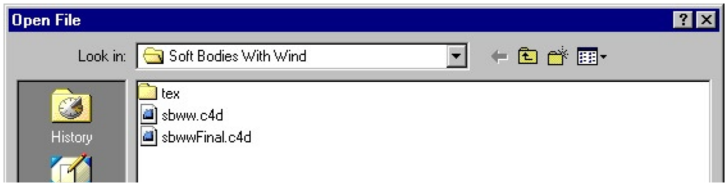
One thing that we're positive you'll want to use soft bodies for is cloth. In this tutorial we will apply some new dynamics techniques in order to gently ruffle a tablecloth.

There are two ways that polygon objects can act within Dynamics. They can retain their shapes perfectly and never deform — these are known as rigid bodies. The other kind of dynamics object is a soft body; these can ripple like water, deform like foam, stretch like rubber or flow like silk. Soft bodies can be virtually any material we can imagine.

In this tutorial we will use a simplistic model of a tablecloth in order to introduce the concepts of soft bodies and soft springs and how these react to a couple of external forces, wind and gravity. To this purpose we will suspend exact realism so that the basic principles are clear to us.

► **Select File > Open. Navigate to the Soft Bodies With Wind tutorial folder on your Documentation CD and open the file named 'sbww.c4d'.**

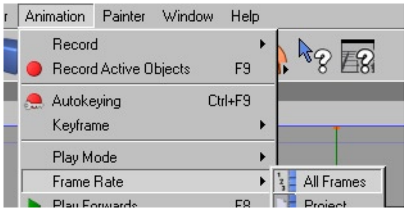
Find the 'sbww.c4d' project and load it; here you will find a tablecloth we have prepared ready for animation. The Tutorials folder is in the Dynamics module folder. Each tutorial in this manual has its own folder within the main Tutorials folder.



This will open our tablecloth project with all modelling and lighting set up and ready for us to begin adding a dynamics simulation. We can see three objects in the Object manager. The Scene object is the rest of the scene and is hidden to make working on the scene quicker: the objects in here will appear when we render. Also visible is a HyperNURBS object which contains a Cloth object. The actual geometry on the tablecloth is quite simple, the HyperNURBS object is there to smooth it all out.

▶ **Ensure that Animation > Frame Rate > All Frames is enabled.**

We must make sure that we view each and every frame of the simulation rather than every 10 or so.



When using dynamics we need to be able to see every frame; this enables us to check that every frame is how we want it to look, plus it prevents the dynamics from calculating many frames at once, which can be slow on some complex scenes. When working with dynamics we should make it a habit to ensure that All Frames is enabled.

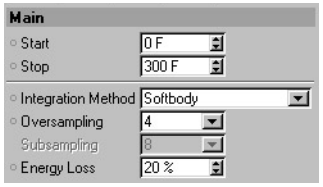
▶ **Select Plugins > Dynamics > Solver Object.**

All dynamics animations need to be set up using special objects that control how the dynamics system will run. The most important object is the dynamics solver, which actually does all the calculation — it literally solves the maths.

We can add as many Solver objects to a scene as we wish, each containing discrete dynamics systems, therefore each system can be optimised to suit the particular types of systems they contain.

▶ **On the Solver object's Main tab, set the Stop frame to 300, the Integration Method to Softbody and leave the Oversampling set to 4. Set the Energy Loss to 20%.**

Soft body simulation is quite complex so we are speeding things up using the optimized Softbody integration method.



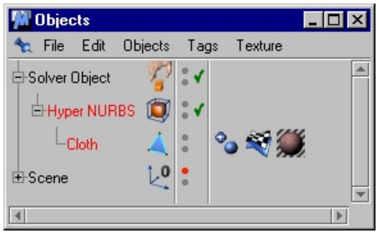
Main

Start	0 F
Stop	300 F
Integration Method	Softbody
Oversampling	4
Subsampling	8
Energy Loss	20 %

The Energy Loss has been set to 20%, this stops the flapping of the cloth from building up.

▶ **Drag the Hyper NURBS object into the solver.**

All objects to be taken into account during the calculations must be inside the solver.



To speed up workflow, only objects which are children of a Solver object will be taken into consideration when calculating the next frame of the simulation.

You may be wondering why we shouldn't just throw everything into a single Solver object. Imagine you have two totally separate dynamics simulations in a scene, let's say a game of pool and some clothing on a character. If they were both in the same Solver object then everything would play back at a much slower rate as the dynamics would be constantly checking to see if any of the pool balls had collided with the cloth.

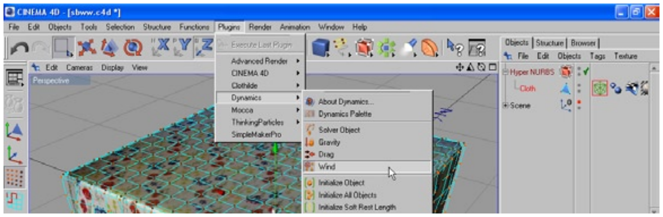
If they are in unique Solver objects then Dynamics knows not to bother checking — each Solver object is its own mini simulation and does not care about anything else that might be going on.

▶ **Select Plugins > Dynamics > Gravity.**

As this simulation is taking place on Earth we will need some downwards gravity to keep the cloth draped naturally over the table.

▶ **Select Plugins > Dynamics > Wind.**

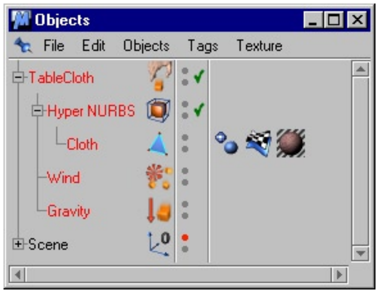
We need to add wind, without it our tablecloth has no reason to move.



Without any external forces being applied to the tablecloth, nothing would move. It is already modelled in a naturally draped state, so gravity alone will not cause it to move. The wind is our external force.

▸ **Drag both forces into the solver.**

Just like the tablecloth geometry, the forces need to be inside a solver for them to know which objects to affect.



TableCloth
Hyper NURBS
Cloth
Wind
Gravity
Scene

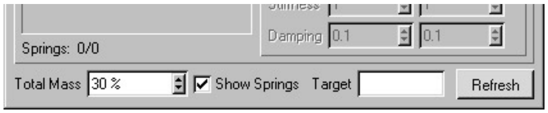
Just like the geometry, the two forces need to be within the solver for them to affect anything.

▸ **In the Object manager, select the Cloth object and select File > Dynamics Tags > Soft Body Spring.**

So what do springs have to do with soft bodies? Dynamics works by connecting together as many points as you like with many small springs. When you pull on one, the energy is transferred throughout the object. If these springs are very tight and stiff then it will act like a thick and strong material, such as a potato sack or heavy denim. Having very stretchy but inflexible springs will give a floppy rubber sort of effect. More flowing materials, such as silk or water, can be simulated by making the springs tight but very flexible.

▸ **In the Soft Body dialog, set the Total Mass to 30%.**

When certain points have no masses, none of the forces will influence them. Later we will use this feature to keep the top of the tablecloth still.

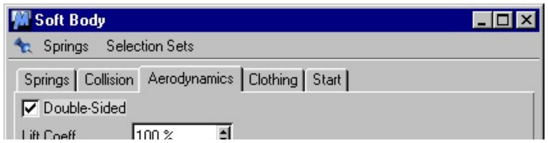


Springs: 0/0
Damping 0.1 0.1
Total Mass 30 %
☑ Show Springs
Target

The default total mass of 100% is too much; this would give the impression that the tablecloth is very heavy or that there is a very strong gravitational influence.

▸ **Click the Aerodynamics tab and enable the Double-Sided option.**

Double-sided polygons enable us to save processing power by using objects which are just a single polygon thick.

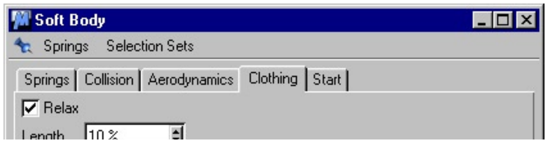


☑ Double-Sided
Lift Coeff 100 %

Which way something should move when calculating lift (aerodynamics, in other words) depends on the direction of the object's surface normals. If our tablecloth were perfect then it would actually have some thickness to it and we wouldn't need to bother with this step. But as it is actually just a polygon with no thickness, if wind hits the back of it then it will have no effect on it whatsoever. We can tell Dynamics to make our polygons double-sided so that the wind can blow both sides.

▸ **Click the Clothing tab, enable the Relax option, click Refresh, then close the Soft Body dialog.**

Compared with other woven materials, our tablecloth is quite inflexible. Here we are spreading the movement energy around the cloth by enabling the Relax option.



☑ Relax

Length 10 %

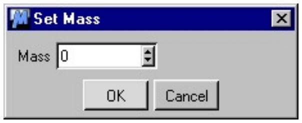
The Clothing tab is there to help improve the motions of clothing. The Relax option will help to disperse the energy around the entire object. Length decides how far from the source of movement the energy will be transferred, Depth determines how much of this energy is distributed.

▸ **Select the Cloth object and double-click on the Cloth's first (left-most) Point Selection tag.**

We have already set up two point selections for the Cloth object. The first of these is the top of the tablecloth.

▸ **Select Plugins > Dynamics > Set Soft Mass, and set the Mass to 0.**

Zero mass objects can be keyframed or, in our case, not moved at all.

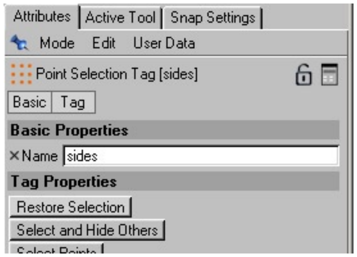


Mass 0

We have now set the mass of all top points to zero; this means that they will not be blown by the wind, nor will they fall under the influence of gravity. Here we are basically cheating. Because the top of our tablecloth won't move, it will look as if there is a solid table underneath — as viewers will never actually see under the tablecloth, they will never know the difference.

▸ **In the Object manager, double-click on the Cloth's right-most Point Selection tag, then in the Attribute manager click the Restore Selection button.**

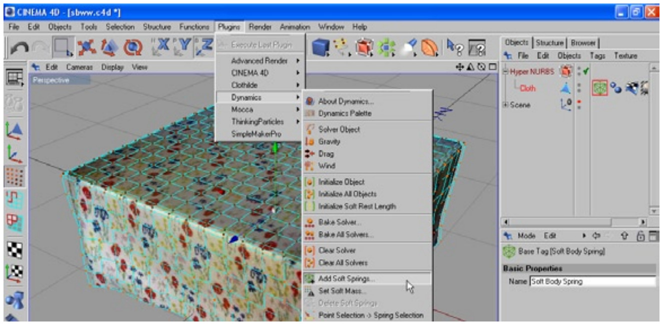
The second point selection is a collection of all the points we want to move.


Attributes | Active Tool | Snap Settings
Mode Edit User Data
Point Selection Tag [sides]
Basic | Tag
Basic Properties
Name: sides
Tag Properties
Restore Selection
Select and Hide Others
Select Points

The second point selection covers all of the points around the side of the tablecloth, the ones which we want to flap in the wind.

▸ **Select Plugins > Dynamics > Add Soft Springs.**

Even with a Soft Body Spring tag our tablecloth has no springs yet. This function will add some.

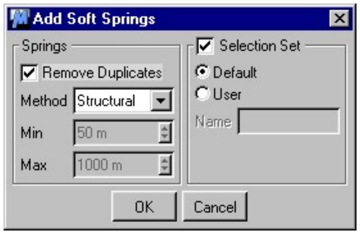


Base Tag [Soft Body Spring]
Basic Properties
Name: Soft Body Spring

This opens the Add Soft Springs dialog. From here we can choose how different layers of springs can be added to the tablecloth.

▸ **Set Method to Structural and click OK.**

Structural springs are the only springs which can be safely used on their own.


Add Soft Springs
Springs
☑ Remove Duplicates
Method: Structural
Min: 50 m
Max: 1000 m
☑ Selection Set
● Default
○ User
Name:
OK | Cancel

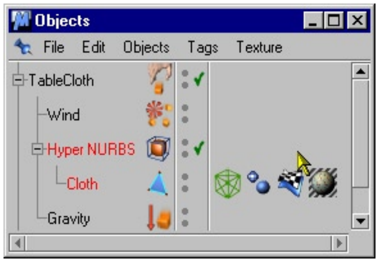
There are several different types of springs we could add. We need to add only structural springs as there will be virtually no diagonal movement in our tablecloth.

Structural springs cover our objects in a grid, ensuring that every point is connected to at least one other. The downside of using structural springs on their own is that they can fold like a trellis and make an object look as if it is elongated, even though none of the springs have stretched. This will not affect our tablecloth because the geometry has been constructed in such a way that no diagonal movement happens.

We can now see the springs we've created displayed in the viewport as red or green lines. Springs selected in the Soft Body Spring tag are displayed green, unselected springs are displayed red.

► **Click on the Wind icon to display its settings in the Attribute manager.**

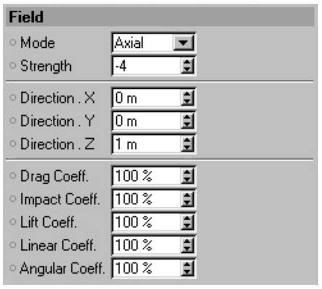
In the Object manager the Wind object is represented by a multiple bladed fan.



We will now add some external force to our scene in the form of a gust of wind.

► **On the Field tab set the Strength to -4.**

Using a negative strength for wind will have the effect of blowing in the opposite direction to which the fan is pointing.



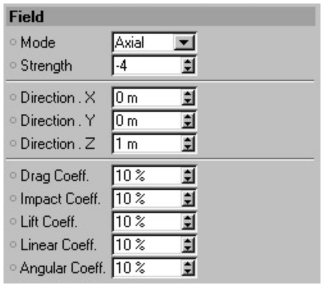
Field

Mode	Axial
Strength	-4
Direction . X	0 m
Direction . Y	0 m
Direction . Z	1 m
Drag Coeff.	100 %
Impact Coeff.	100 %
Lift Coeff.	100 %
Linear Coeff.	100 %
Angular Coeff.	100 %

Even though we have reduced the mass of the tablecloth, it is still fairly heavy, meaning the wind will have to be stronger than the defaults in order to lift the material. The minus sign is there to blow the wind in the opposite direction, towards us that is.

► **Set all of the aerodynamic coefficients (Lift, Impact and Drag) to 10%.**

The default settings have the flying abilities of a brick. To give our tablecloth some lift we alter the settings in this dialog.


Field

Mode	Axial
Strength	-4
Direction . X	0 m
Direction . Y	0 m
Direction . Z	1 m
Drag Coeff.	10 %
Impact Coeff.	10 %
Lift Coeff.	10 %
Linear Coeff.	10 %
Angular Coeff.	10 %

To keep our dynamics simulation as fast as possible we have avoided the use of collision detection for the soft bodies. This would require some humongous calculations and they should be avoided where possible. For this reason we want to make sure that the tablecloth doesn't get blown so hard that it passes up through itself, and reducing the three coefficients will achieve this.

► **Click Play to see the simulation play.**

We will see that the top of the tablecloth remains stationary while the sides blow, inflate and ripple realistically towards the camera.

Summary

We've learned in this tutorial that it is not required to add soft springs to each and every part of our object, and sometimes it is not essential to apply dynamics to every part of an object. Even though in the real world all parts of a tablecloth will flap around, we can save ourselves time by using springs only where they will be noticed.

This is just one application for soft body springs, you will find more tutorials in this manual covering different aspects and uses of them.

Self Collision

Self Collision

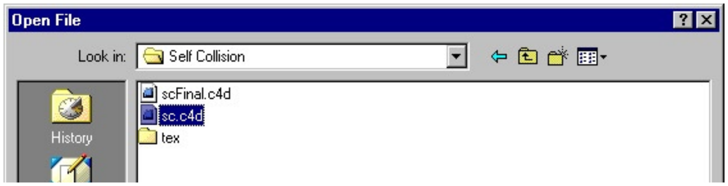
Unless we specifically tell them not to, soft bodies have a habit of intersecting themselves as they deform. Here we will utilise soft body springs and full collision detection to make some curtains flap in the wind.

This tutorial builds on the Soft Bodies With Wind tutorial. If you haven't completed that previous tutorial then we recommend you do so before starting this one.

In this Self Collision tutorial we will learn about applying soft body springs only where needed and also how to make them collide with self collisions to create a convincing pair of curtains blowing in the wind. By adding soft body collisions we will be able to use a strong wind which will cause the curtains to collide with themselves. Without the self collisions they would simply pass through themselves in an unconvincing way. Also featured here is one use of keyframes in a dynamics simulation.

▸ **Select File > Open. Navigate to the Self Collision tutorial folder on your Documentation CD and open the file named 'sc.c4d'.**

Load the ready modelled scene; here we will find the pair of curtains to be simulated. The Tutorials folder is in the Dynamics module folder. Each tutorial in this manual has its own folder within the main Tutorials folder.



Here we will find a scene with two identical curtains already folded and draped in a realistic pose. We could quite easily get them into this position by starting with flat planes and allowing them to sag naturally, but loading this scene will save us a bit of time.

▶ **Ensure that Animation > Frame Rate > All Frames is enabled.**

Remember, when working with dynamics we should make it a habit to ensure that All Frames is enabled.

▶ **Select Plugins > Dynamics > Solver Object.**

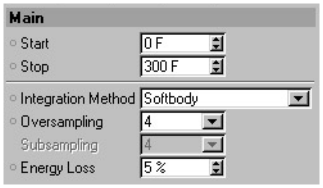
We hope you will have completed one of the easier tutorials before diving into the deep end here, so you will know by now that a Solver Object is required before any dynamics simulation can take place.

▶ **On the Solver object's Main tab, set the Stop frame to 300.**

Our project lasts for 300 frames. If the Stop frame were left at its default then the simulation would end before the animation had finished.

▶ **Set the Integration method to Softbody and the Oversampling to 4.**

The default solver settings are too inaccurate for soft body springs.

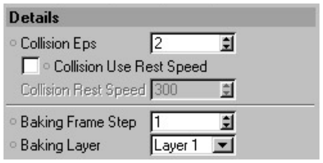

Main

Start	0 F
Stop	300 F
Integration Method	Softbody
Oversampling	4
Subsampling	4
Energy Loss	5 %

For this scene in particular it is especially important to use the Softbody integration method. This method is much faster to calculate for this type of simulation than the other methods, especially so later on when we come to turn on collision detection.

▶ **On the Details tab set the Collision Eps to 2.**

Low Eps values generally work best when using the Softbody integration method.

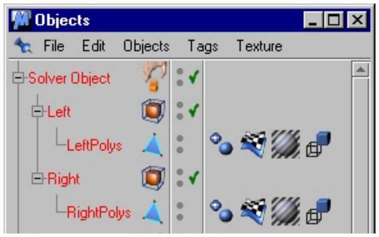

Details

Collision Eps	2
☐ Collision Use Rest Speed	
Collision Rest Speed	300
Baking Frame Step	1
Baking Layer	Layer 1

When using the Softbody integration method it's usually best to set the Eps to a low value — high values can lead to an unstable simulation!

▶ **In the Object manager, drag the Left and Right objects into the solver.**

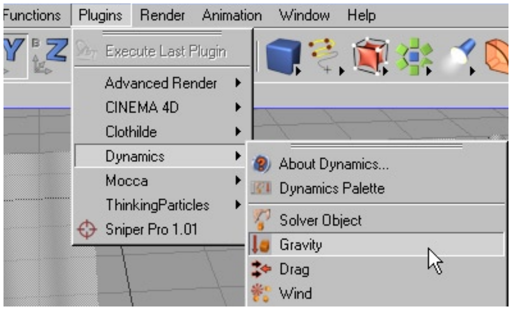
The Left and Right objects are our two curtains, they must be children of the Solver object.



Only the children of a Solver object will be affected by dynamics, any objects outside of this will be completely ignored, even if they are inside a different Solver object.

▶ **Select Plugins > Dynamics > Gravity.**

With no gravity the curtains would float upwards when blown.



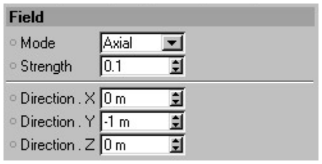
Without gravity, our curtains would have no reason to fall back after being blown. Adding a Gravity object will cause them to drape naturally.

▶ **Click on the Gravity icon.**

By clicking on an object's icon we will be presented with any options available for that object.

▶ **On the Field tab set the Strength to 0.1.**

Depending on the scale of our scene, we may need to increase or decrease the gravity strength. Here we need to decrease it.


Field
Mode: Axial
Strength: 0.1
Direction . X: 0 m
Direction . Y: -1 m
Direction . Z: 0 m

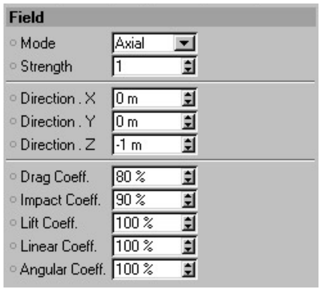
To stop the curtains from falling too quickly we are reducing the strength of the gravity. Another way to do this would be to increase the level of drag, however this would also slow the upward movements when blown by the wind.

▶ **Select Plugins > Dynamics > Wind.**

Seeing as this tutorial is about curtains blowing in the wind, the Wind object will play a vital role here.

▶ **On the Field tab set Direction.Z to -1 and the Lift, Impact and Drag coefficients to 80, 90 and 100 respectively.**

We can choose to blow the curtains inwards along -Z or outwards along +Z.

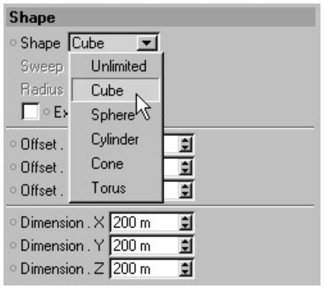

Field

Mode	Axial
Strength	1
Direction . X	0 m
Direction . Y	0 m
Direction . Z	-1 m
Drag Coeff.	80 %
Impact Coeff.	90 %
Lift Coeff.	100 %
Linear Coeff.	100 %
Angular Coeff.	100 %

Setting the direction to -1 on Z and reducing the strength will cause a soft breeze to blow the curtains into the café. These numbers are not essential values, feel free to alter them for a lighter breeze or turn them up to create a gale. When experimenting, try to use reasonable values — setting a wind strength of 1,000, for example, could cause problems.

▶ **Click on the Shape tab and set the Shape to Cube.**

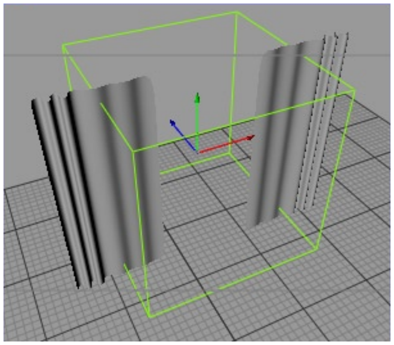
Restrict the area of influence for the wind by giving it a specific shape rather than being everywhere.



Shape	Cube
Dimension . X	200 m
Dimension . Y	200 m
Dimension . Z	200 m

► **Using the Object tool, scale and move the green cube of wind so that it covers the inside half of both curtains.**

Reposition the wind so that only certain parts of the curtains are blown; this will make the motion more interesting.

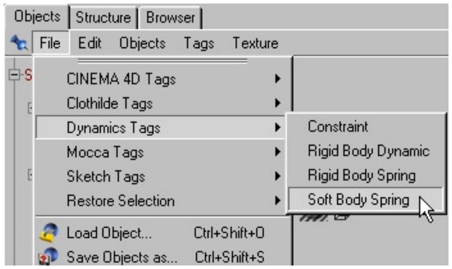


If we look at the curtain model we will see that the edge near the wall is all crumpled up, as if it has been pulled open, and that the inside edge is quite spread out. The waves on the outside of the curtains will make that part of them more rigid and less likely to move.

We are now going to add soft springs to the left-hand curtain. When we have finished this we will need to return to this point of the tutorial and repeat the process to add springs to the right-hand curtain.

► **In the Object manager, select the object named LeftPolys then select File > Dynamics Tags > Soft Body Spring.**

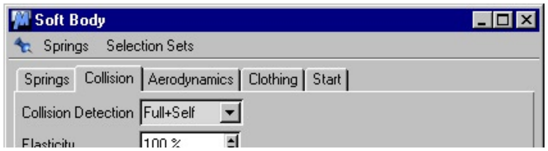
A Soft Body Spring tag holds a list of all soft springs applied to a particular object.



Until we add a Soft Body Spring (SBS) tag the object will remain rigid and stationary as it has no reason to move. The SBS tag will enable the object to flex and bend under the influence of the dynamics objects.

► **Click on the Collision tab and set the Collision Detection to Full+Self.**

Self collision detection can be used to prevent an object from intersecting itself as it deforms.

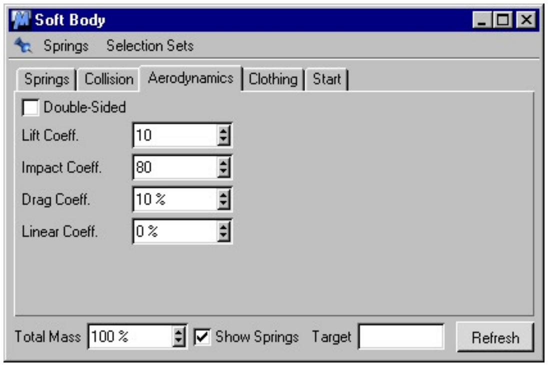


Collision Detection: Full+Self
Elasticity: 100 %

By enabling self collisions, the curtains will not be able to pass through themselves if the wind should blow them into such a position.

► **Click on the Aerodynamics tab and set the coefficients: Lift to 10, Impact to 80, Drag to 10 and Linear to 0.**

As the curtain changes shape, so will its aerodynamic properties; we can set these up here.



☐ Double-Sided
Lift Coeff.: 10
Impact Coeff.: 80
Drag Coeff.: 10 %
Linear Coeff.: 0 %
Total Mass: 100 %
☑ Show Springs
Target:

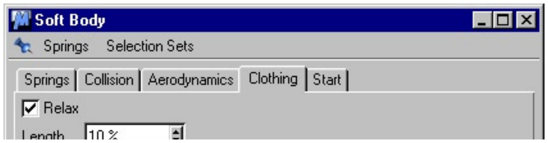
A small amount of lift is used because these are net curtains and some of the wind will actually pass through the fine mesh, destroying most of the lift properties it would have had. Impact is essential for the curtains to move when the wind blows — this should be used for anything we want to be blown about such as sails, clothing or curtains.

► **Enable the Double-Sided option.**

Our curtains are only one polygon thick, but they need to be blown both into the room and back out again. Enabling the Double-Sided option means that the wind ignores the surface normals during the lift coefficient calculations.

► **Click the Clothing tab and enable the Relax option. Click on Refresh and close the dialog.**

The Relax option is very useful for creating flowing cloth effects.



☑ Relax
Length 10 %

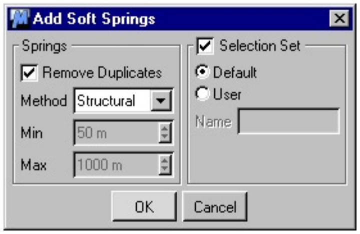
Although curtains are flexible, they stretch very little. For example, if we prodded one with a finger the entire curtain would shift to compensate rather than form a small peak where our finger is, which would happen only if the curtains were dense and heavy.

► **Select Plugins > Dynamics > Add Soft Springs.**

Even though the object has a Soft Body Spring Tag, it doesn't actually have any springs yet. There are various different types of spring which can be added.

► **Set the Method to Structural then click OK. Again select Plugins > Dynamics > Add Soft Springs and this time set the Method to Flexion and click OK.**

Uniform structural springs are suitable for the curtains.

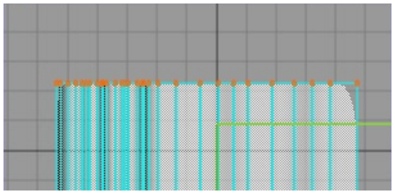


☑ Remove Duplicates
Method Structural
Min 50 m
Max 1000 m
☑ Selection Set
● Default
○ User
Name

These structural springs will run throughout the curtain in a grid, linking each point to at least two others. This will allow the curtain to bend and flex very sharply, but will maintain the same basic proportions.

▶ **Enter point selection mode and select the top row of points on the LeftPolys object.**

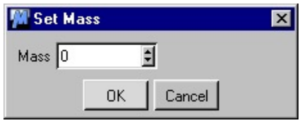
Using whichever selection tool we prefer, we select the points we do not wish to fall due to gravity.



Currently the curtain will fall under the influence of gravity, to prevent this we need to select certain points which we do not want to move. As this is a curtain it should be held at the top.

▶ **Select Plugins > Dynamics > Set Soft Mass, set the Mass to 0 and click OK.**

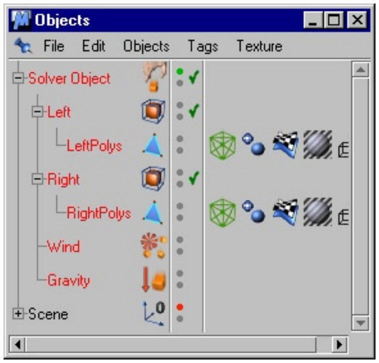
Setting the mass of any object to zero tells Dynamics that keyframes should be used to animate it instead of the calculated simulation.



Objects or parts of objects with no mass cannot be moved by Dynamics. These objects will remain stationary unless they are moved by traditional keyframes. As the row of points at the top can no longer move, the springs will hold the object together and give a realistic motion when blown.

▶ **Drag the Gravity and Wind objects into the solver.**

As with all Dynamics force fields, to enable them we must make them children of a Solver object.



For the wind and gravity to be taken into account when running the simulation, they must be children of the Solver Object.

► **Press the Play button to see the simulation begin.**

When we are satisfied we will need to return to an ealier point in this tutorial (see the red box from a few pages back) and repeat the process to add springs to the right-hand curtain. Then we can set a path and save format from the Render Settings and then render out the finished animation.

Summary

Here we have made the curtains realistically blow in the wind and, depending on the exact settings, slide against themselves. We should by now realise that collisions do not always have to be large and pronounced. Often it is better that the simulation is so well crafted that the viewer does not notice it happening.

If you find the playback rate in the viewport is too slow to see the motion of the curtains, you may want to temporarily disable collision detection to reduce the burden on the processor. If possible you should also enable OpenGL (General Settings) as this will reduce the amount of CPU time needed even further.

CINEMA 4D

Release 9

Dynamics Reference

Force Fields

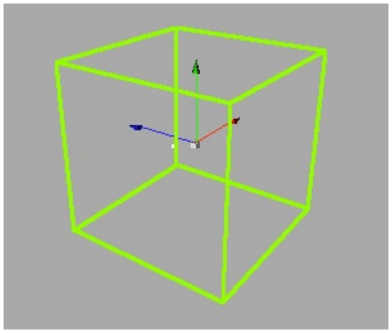
Motion is affected not by one force but by a variety of forces such as gravity, wind and drag. Using fields, you can simulate these forces of nature to increase the realism of your dynamics animation.

If dynamics motion is to look real, it will need to take into account forces like gravity, drag and wind. It is precisely these forces that you can simulate using fields. Your dynamics animation will usually include at least one field. A field exerts a force on objects that are inside the field. In the case of a free-moving object, this force will cause the object to accelerate or decelerate depending on the direction of the field and the direction of the object.

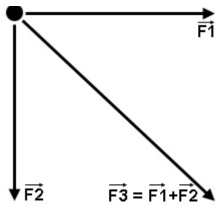
Fields in Dynamics are easy to use, but a few basic concepts — described in the following — will help to explain when and how you should use fields.

For illustration purposes, a field will be represented in this manual as a number of lines of force that point in the direction of the force. Note that the lines of force will not be shown in the CINEMA 4D viewport.

A field can have one of a variety of shapes, such as cubic or spherical. The shape defines the volume inside which the field will exert a force on objects, i.e. the shape marks the boundaries of the field. It is also possible to give a field an unlimited shape, in which case the field will exert its force throughout 3D space without boundaries.


A force field in the viewport. The boundaries of a field are shown as a green outline.

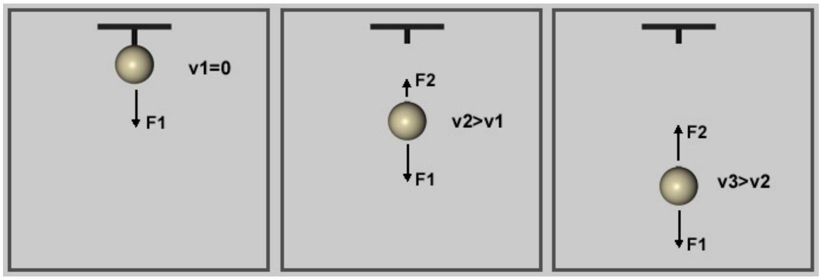
A moving object is usually subjected to not just one but a number of forces at any given time. Hence Dynamics enables you to place as many force fields as you need over the same volume of 3D space. The forces exerted on an object by overlapping fields will be added together under the laws of physics to ensure correct motion.



Two forces, F1 and F2, are acting on a point (top left). These two forces will be added under the laws of physics to produce the correct resultant force, F3.

The diagram below demonstrates how a variety of forces can affect even a simple motion.

Even a simple motion like a sphere falling under gravity is subjected to numerous forces over the course of its motion. Fields enable you to simulate all of these forces.



In the left-hand picture the sphere is initially being held in place by a peg. F1 is the force due to gravity. Not shown is the holding force that prevents the sphere from moving. This holding force is equal and opposite to F1, hence the forces are cancelling each other out and there is no resultant motion.

In the middle picture the peg has been removed and with it the holding force. As a result, the sphere is accelerating towards the floor due to gravity. Now that the sphere is moving, a new force, drag (F2), is being applied. Drag always exerts its force in the opposite direction to the object's motion, hence F2 acts in the opposite direction to F1. Drag is not a constant force but instead increases with increasing fall velocity. At this stage, F2 is less than F1, causing the sphere to accelerate.

In the right-hand picture the drag force is now equal and opposite to the gravity force. The forces are cancelling each other out, so the object is no longer accelerating but instead falling with constant velocity (v3).

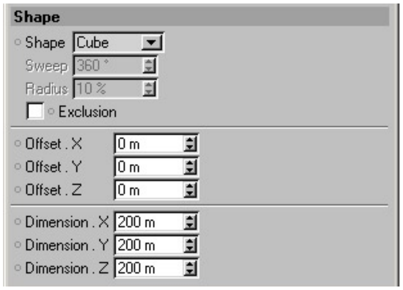
The falling sphere example demonstrates that a motion is not always as straightforward as it may first appear. But by using fields, you can simulate these forces and let Dynamics handle the interaction and computation. All this and more can be simulated with the three types of field available: gravity, wind and drag.

Gravity

Gravity is the most commonly used force. With it you can simulate most types of motion including collision. The force exerted on an object by gravity depends on the object's mass. To switch off gravity for any given object in the dynamics system, set the Mass of the object to 0. This will also switch off wind and drag for the object. Gravity fields are also useful for simulating collision. Although Dynamics includes a collision detection engine, collision via gravity fields can be many times faster.

Shape Tab

The Shape tab enables you to modify the volume inside which the field will exert a force on objects.

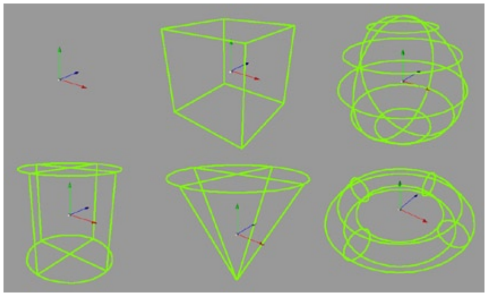


Shape

Shape	Cube
Sweep	360 °
Radius	10 %
☐ Exclusion	
Offset . X	0 m
Offset . Y	0 m
Offset . Z	0 m
Dimension . X	200 m
Dimension . Y	200 m
Dimension . Z	200 m

Shape

Here, set the general shape of the field. Choose from Unlimited (exerts force throughout 3D space), Cube, Sphere, Cylinder, Cone and Torus.

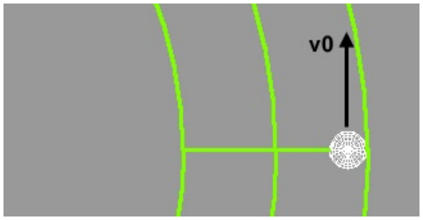


A field can take one of the following shapes (left to right, top to bottom): unlimited, cube, sphere, cylinder, cone, torus.

The field will usually exert a force on any object that are inside the shape (provided that Exclusion is disabled — see Exclusion, below).

The Torus shape is particularly useful for generating circular motion. This can be achieved by using a Radial field with Exclusion enabled. In additional, the object should be given a starting velocity (v0) that is tangential to the torus pipe cross section, as indicated in the diagram below.

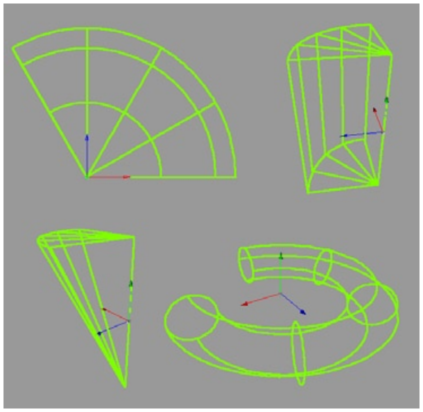
The torus shape is ideal for creating circular motion.



Sweep

For the shapes that demonstrate rotational symmetry (Sphere, Cylinder and Torus), you can additionally restrict the field to just a section of the shape.

Some example sweeps: 120° sphere, 90° cylinder, 90° cone, 270° torus.

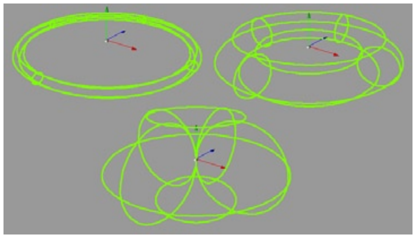


The default Sweep value is 360°, which corresponds to the entire shape. To restrict the field to just a section of the shape, enter a value less than 360°. For example, to define a hemispherical field, set Shape to Sphere and Sweep to 180°.

Radius

You can enter a value only if Shape is set to Torus.

The Radius defines the radius of the torus tube as a percentage of the entire torus radius. You can enter a value from 0% to 100%.

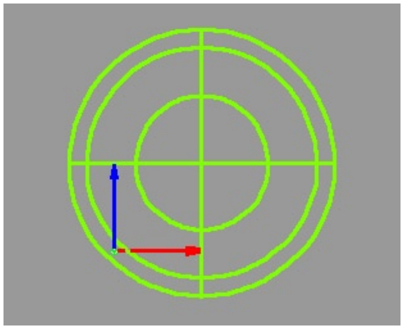

A torus shape with radius set to 10%, 40% and 100%.

Exclusion

This option is enabled by default. When it is enabled, the field will exert its force *outside* the shape as opposed to inside. One possible usage is to allow the field to 'capture' objects — when an object leaves the shape, a force can be exerted that will pull the object back towards the shape.

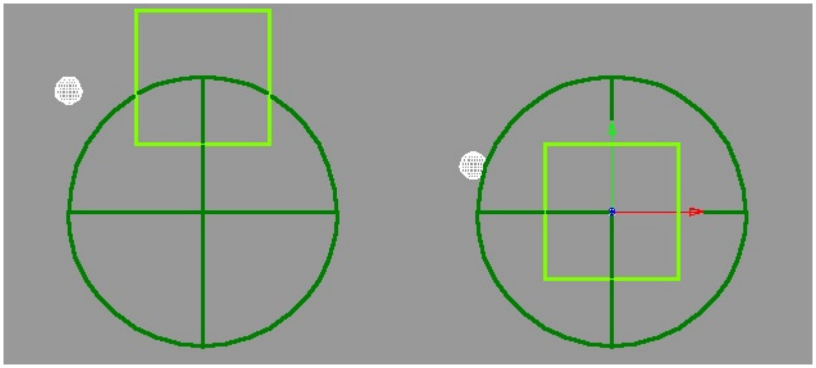
Offset

This enables you to offset the shape of the field away from the origin. This is useful with the Radial field only, where the origin defines the source of attraction or repulsion. By using the Offset values with the Radial field, you can effectively move the source of attraction or repulsion away from the centre of the shape.


Here the Offset parameters have been used to move a radial field's spherical shape away from the origin. Provided that Strength is set to a positive value and Exclusion is disabled, objects inside the shape will now be attracted towards the bottom left rather than towards the centre of the field. This is because the origin defines the centre of attraction or repulsion.

A falloff (Falloff tab) will always refer to the field's origin, not to the centre of the shape. This is explored in the diagram below.

Two small white spheres, both moving to the right, are about to enter a Radial field whose Shape is set to Cube. Of the two spheres, the one on the left will experience less force. Due to the offset shape, the left-hand sphere will pass through the edge of the falloff (dark sphere) only.



In the diagram above are two Radial fields with Shape set to Cube. The shape of the left Radial field has been offset above the origin. Note how the left field's falloff (dark sphere) is not offset but instead remains centred on the origin. Apart from the shape offset, the two Radial fields are identical.

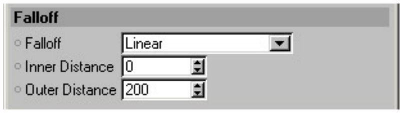
When the two spheres (travelling from left to right) enter their fields, the left sphere will experience much less force than the right sphere. Although the left sphere will pass through the centre of the shape, it will pass through the edge of the falloff and experience only a fraction of the full force. The right sphere will experience more force than the left sphere because it will pass through a field region with less falloff.

Dimension

Here you can set the dimensions of the field numerically. Alternatively, use the Scale tool to resize interactively in the viewport.

Falloff Tab

A falloff enables a smoother interaction with objects because the force will increase gradually rather than abruptly as the objects move into the field.



Falloff

Falloff	Linear
Inner Distance	0
Outer Distance	200

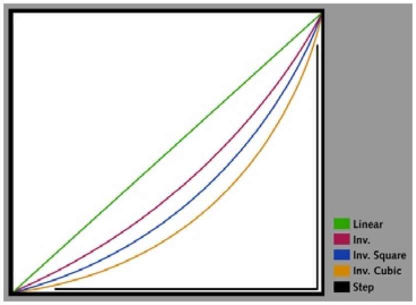
The parameters on this tab enable you to define a falloff for the field so that the strength of the force will increase gradually towards the centre of the field as opposed to uniform force strength throughout the field.

A falloff enables a smoother interaction with objects because the force will increase gradually rather than abruptly as the objects move into the field.

Falloff

Choose the type of falloff: None (the default), Linear, Inv. (Inverse), Inv. Square, Inv. Cubic or Step.

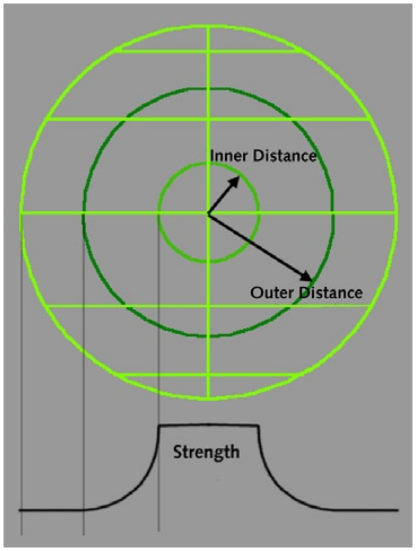
Falloff types. With Step there will be an abrupt transition from no force to maximum force.



Inner Distance, Outer Distance

The Inner Distance and Outer Distance values determine the start and end distances respectively from the origin over which there will be a falloff of the force.

The Inner Distance and Outer Distance define the volume in which the falloff of force will happen.



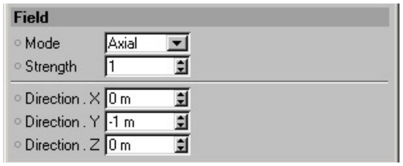
The example above shows a spherical field with an Inner Distance and Outer Distance defined. Within the Inner Distance, the full strength of the force will be exerted.

When an object is between the Inner Distance and Outer Distance, the strength of the force exerted on the object will falloff according to the function defined under Falloff. When an object is outside the Outer Distance, the field will exert no force on the object.

You can define the Outer Distance to be larger than the field itself. However, an object will experience a force only when it is inside the field's shape.

Field Tab

Using the Field tab you can define the type, strength and direction of the gravity field.

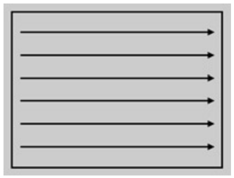


Field

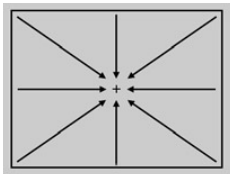
Mode	Axial
Strength	1
Direction . X	0 m
Direction . Y	-1 m
Direction . Z	0 m

Mode

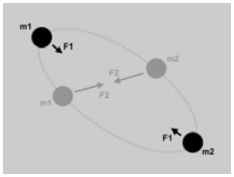
Use Field to set the type of gravity field required. Three types are available: Axial, Radial and Newton.



Axial



Radial



Newton

Axial

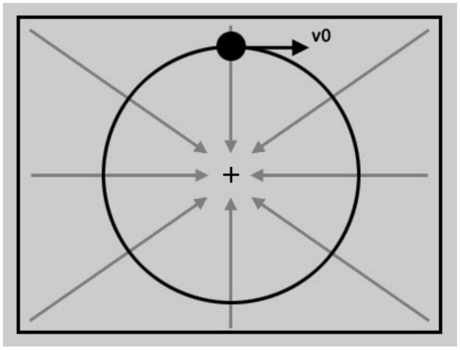
The lines of force in the Axial field run parallel to each other. Hence an object that is inside the Axial field will be accelerated in one direction only, as specified under Direction.

Radial

The Radial gravity field will attract objects towards its centre if a positive Strength value is used. With a negative Strength value, the field will repel objects away from its centre.

The Radial field can also be used to create circular motion. The object will need a starting velocity (v0) and it should be placed at the top of the field with its movement at a right angle to the line of force.

With a suitable starting velocity and direction, an object in a Radial field will travel in a circle.



You will need to experiment in order to find a suitable value for v0. If the object is plunging towards the centre of the field, you will need to increase v0. If the object is escaping the field, you will need to decrease v0.

The Radial field also offers you an alternative to CINEMA 4D's native explosions system. To explode in all directions, placing some fragments inside the field and set Strength to a negative value.

Newton

The Newton field is not a single field. Rather, a Radial field will be placed inside each rigid body and soft body in the solver object. Hence all the bodies will exert a force on each other. If the Strength value is positive, the bodies will exert a force of attraction. With a negative Strength value, the bodies will repel each other.

One of the most important factors is the Mass of each body. The greater the body's mass, the greater its force of attraction or repulsion.

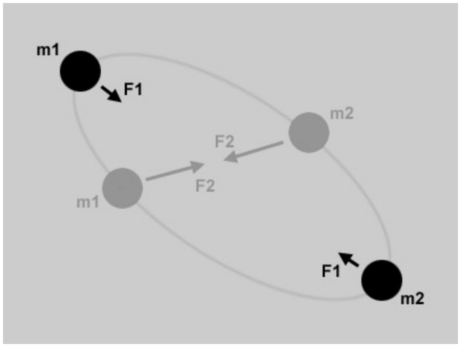
The distance between the bodies is also a key factor. The force of attraction or repulsion will weaken with increasing distance.

The formula for the force is:

$$F = m1 * m2 / (r*r)$$

i.e. the force is proportional to the mass of the bodies and inversely proportional to the square of the distance between the bodies. If you were to double a mass, the force would be doubled. If you were to halve a mass, the force would be halved.

The Newton field can be used to create elliptical paths, making it suitable for planetary orbits.



Shown above are two rigid bodies that have been placed in a Newton field. If the motion is drag-free — like motion in outer space — the bodies will travel along an elliptical path. This is because the force of attraction will increase as the bodies near each other. It is this principle of attraction that explains why the planets in our solar system orbit the sun. The sun itself remains largely unaffected by the pull of the planets due to its enormous mass. So to simulate planetary orbits, you should use the Newton field.

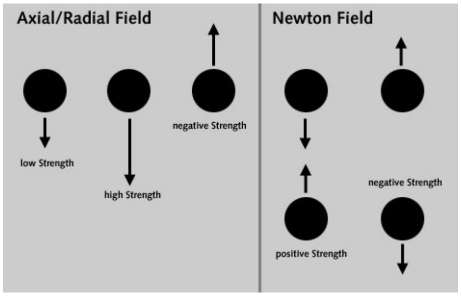
The Newton field has many other uses besides planetary orbits. In particular, it can simulate collision detection such as pool balls bouncing off each other. Although you could alternatively use the collision detection engine, collision via gravity fields is much faster to process.

To simulate collision detection using a Newton field, enable the Exclusion option (Shape tab) and set Falloff to Step (Falloff tab).

Strength

Strength defines the size of the force exerted by the field. You can enter a positive value or a negative value. In the case of a Newton field, a positive value will cause attraction whereas a negative value will cause repulsion.

The effect of a varying Strength value on the Axial, Radial and Newton fields.



Direction

You can set the direction parameters for the Axial field only. To define the direction of the lines of force in the Axial field, enter a vector (X,Y,Z) under Direction. This setting refers to the object's coordinate system. Note that because the direction is defined as a vector, the values 100,10,0 define the same direction as 10,1,0. A value of 0 signifies no force in the corresponding direction. You can enter negative numbers also for negative axis values.

Example

If you set X to 1 and Y to 1, the resultant direction of the force will be at the 45° angle between the X and Y axes. To easily define the angle of force, set one of the X,Y,Z parameters to 1 and leave the other two parameters at their default value of 0. Then use the Rotate tool to point the field in the desired direction.

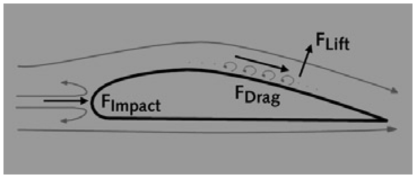
Wind

The wind force takes into account the shape of the object and the surface area that is facing the wind.

In contrast to gravity, wind takes an object's shape into account. Depending on the direction of the wind and the object, various forces will be exerted that will change continually as the object rotates.

Simulating these phenomena with true accuracy would involved extremely complex equations, where even a simple motion could take hours to compute.

Dynamics simplifies the aerodynamics calculation to produce realistic results in a fraction of the normal processing time. This simplification involves breaking down the forces that act on the object into three main types: lift, impact and drag.

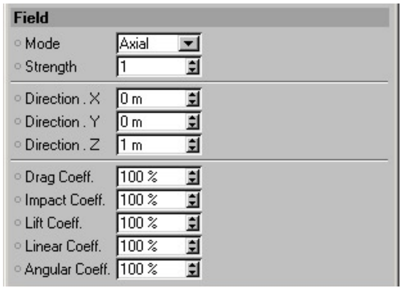


With Dynamics, wind is simulated using three key forces: lift, impact and drag. The diagram shows these forces acting on a wing profile.

Shape Tab, Falloff Tab

The parameters on the Shape tab and Falloff tab work in the same way as the parameters of the same name described in the Gravity section above.

Field Tab



Field

Mode	Axial
Strength	1
Direction . X	0 m
Direction . Y	0 m
Direction . Z	1 m
Drag Coeff.	100 %
Impact Coeff.	100 %
Lift Coeff.	100 %
Linear Coeff.	100 %
Angular Coeff.	100 %

Using this tab you can specify the nature of the wind using a simplified parameter set. This simplification allows fast computation while still achieving realistic results.

Field

You can use the Field parameter to select the type of the wind field. Two types are available: Axial and Radial. The Axial and Radial fields function in the same way as their counterparts described in the Gravity section above.

Strength

Here, set the strength of the wind.

Direction

This has the same effect as described in the Gravity section above.

Drag Coeff.

When air streams over a body, small eddies will beat against the body's surfaces, causing deceleration. The Drag Coeff. parameter defines the strength of this effect. This decelerating effect is usually minor but occasionally it can have a telling influence on the object's motion.

Impact Coeff.

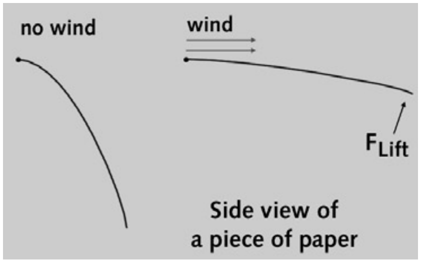
The Impact Coeff. value determines the strength of the air force that will be exerted on body surfaces that face the wind. The strength of the impact force is proportional to the surface area facing the wind and the relative velocity of the body compared to the wind.

Lift Coeff.

This setting defines the strength of lift.

When an airstream passes over a surface, the air pressure will drop. The faster this airstream, the lower the pressure. A wing must be shaped so that the airstream will pass over one wing surface more quickly than over the other wing surface. This will create a pressure gradient, causing the wing to experience a lifting force.

If you were to hold out a piece of paper and blow along its edge, the airstream would create lift on the paper, causing the paper to follow the direction of the airstream.

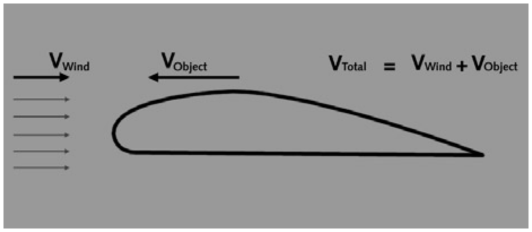


A real-world example of lift. Blow across a hanging piece of paper and the airstream will create a lift force that will raise the paper into line with the airstream.

Note that occasionally paradoxical situations may arise, such as motion that heads into the wind. In such cases you should reduce the Lift Coeff. in one of two places, either in the Wind settings or the Rigid Body Dynamic settings. The latter is usually preferable since it enables you to adjust the lift for a deviant object without affecting the flight of other objects.

Linear Coeff., Angular Coeff.

These two settings relate to linear velocity and angular velocity, which both play a part in an object's motion in the wind field. However, it is not just the wind's velocity that needs to be taken into account, but the object's velocity also.



The velocity will affect an object's behavior in wind. The effective velocity that will be considered is the sum of the wind's velocity and the object's velocity.

Although Linear Coeff. and Angular Coeff. are set to 100% by default, you will need to set values for the Linear and Angular parameters in the Rigid Body Dynamic Tag if you want the velocity to be taken into account. This is because Linear and Angular in the Rigid Body Dynamic Tag are set to 0 (i.e. disabled) by default. In general, leave the parameters in the Wind settings set to 100%, but set their counterparts in the Rigid Body Dynamic Tag to values between 1% and 10% for a realistic result.

Example 1

An aeroplane is taking off at 100 km/h, heading into a wind of 50 km/h. The relative wind velocity that affects the wing's surface is 150 km/h.

Example 2

A plane is taking of at 100 km/h with a following wind of 50 km/h. Hence the relative wind velocity is just 50 km/h. This highlights the reason why aeroplanes will take off from various runways according to the direction of the wind.

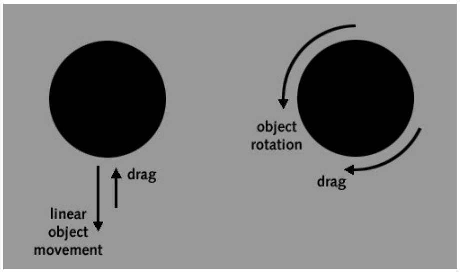
Linear Coeff. defines the strength of this effect for linear motion, whereas Angular Coeff. defines the strength of the effect for angular motion. To switch off the linear of angular effect, set the corresponding parameter to 0.

Drag

The drag field affects moving objects only and it will always exert its force in the opposite direction to the object's motion. Almost all motion is subject to drag of one type or another, so for realistic dynamics animation, you will usually need to use the drag field. Without drag, a body would continue its motion unhindered. A body such as a parachute would never slow down.

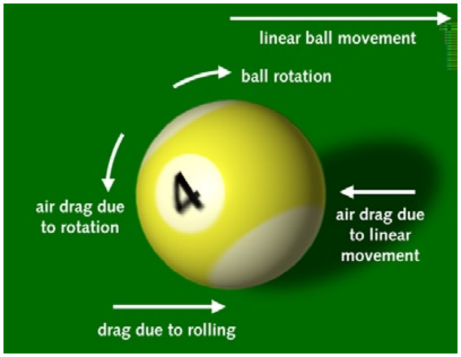
One characteristic of drag is that it always exerts its force in the option direction to the body's motion. This trait is illustrated below.

Drag is always applied in the opposite direction to the body's motion.



Typically, a variety of drag forces will act on an object, as shown in the next diagram. Note that you will not have to concern yourself with all these drag forces when you define the drag field.

Often a variety of drag forces will act on the same object. Here, three types of drag can be seen affecting the motion of the ball.

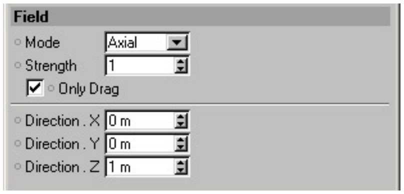


Shape Tab, Falloff Tab

The parameters on the Shape tab and Falloff tab work in the same way as the parameters of the same name described in the Gravity section above.

Field Tab

The Field tab contains parameters for defining the drag's type, direction and strength.


Field
Mode: Axial
Strength: 1
☑ Only Drag
Direction . X: 0 m
Direction . Y: 0 m
Direction . Z: 1 m

On the Field tab you can define the type of drag (angular, linear or axial) as well as its direction and strength.

Mode

Select the type of motion which the drag should affect: Linear, Angular or Axial.

Linear

The drag will affect linear motion, i.e. motion which changes the location of the body. Linear drag will be applied regardless of the direction in which the object is moving.

Angular

This type of drag will decelerate rotating bodies.

Axial

The Axial mode breaks the following law of physics:

Drag will always be applied in the opposite direction to the body's motion.

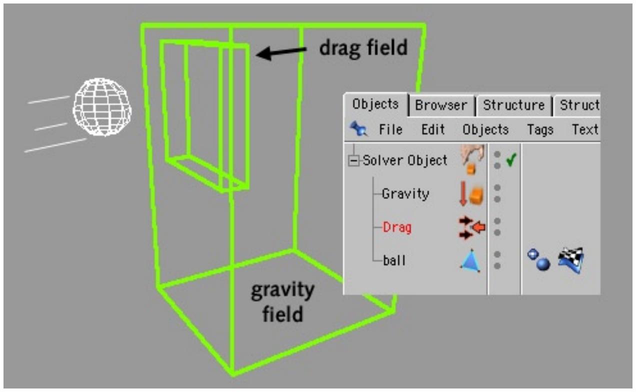
The Axial mode breaks the law by allowing you to specify the direction of the drag (under Direction). Although it defies real world physics, the Axial mode helps you to take short cuts as demonstrated in the example below.

Suppose you want to simulate a soft ball being thrown at a wall. To accomplish this, you could use a drag field to bring the ball to an abrupt halt in the wall region, plus a gravity field to accelerate the ball towards the ground after it has hit the wall.

Although a Linear drag field would be able to halt the ball as it nears the wall, the field would in addition prevent the ball from accelerating towards the floor under gravity. The ball would remain stuck to the wall.

The solution is to use the Axial field, which will exert drag in a defined direction only. By setting the direction of the Axial field force to the opposite direction of the balls initial motion, the drag will stop the ball as it nears the wall yet it will not oppose the downwards motion. The ball will be allowed to fall to the floor.

An Axial drag field will oppose an object's motion in a defined direction only. Here the drag field will stop the ball's horizontal motion, yet it will not oppose the vertical motion when the ball meets the gravity field and falls.



Strength

Use this to set the Strength of the drag force. Enter a high value if the objects should come to an abrupt halt.

Only Drag

This option is available with the Axial mode only. When the option is enabled (as it is by default), the drag will cause deceleration only. If instead the option is disabled, objects will be accelerated by the drag if their motion is pointing in the same direction as the drag force.

Direction

This has the same effect as described in the Gravity section above.

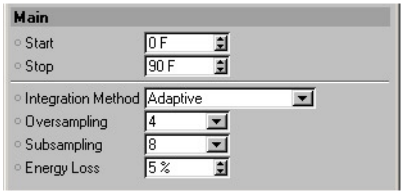
Solver Object

The objects in your dynamics system must be children of a solver object. The solver acts as a container and also specifies the general behavior of the dynamics system such as the accuracy of the animation.

The solver acts as a container for the objects in your dynamics system. Bodies or force fields that are not children of a solver will be ignored by the dynamics engine. But the solver is more than just a container. It has its own settings in the Attribute manager where you can adjust the overall behavior of the dynamics animation such as the accuracy of the motion. A solver is a micro-universe in the sense that it is self-contained. Its children will interact with each other while ignoring objects that are not contained within the solver. The solver's objects will also ignore the children of other solvers, enabling you to use several solvers in the same scene that will run independently of one another.

Without a Solver object, there can be no dynamics.

Main Tab



Main

Start	0 F
Stop	90 F
Integration Method	Adaptive
Oversampling	4
Subsampling	8
Energy Loss	5 %

Start, Stop

These two parameters define when the dynamics animation will begin and when it will stop. The Start and Stop parameters are independent of the project's animation length. If you set Stop to a time point beyond the project length, you will need to increase the Maximum value in the Project Settings dialog.

To move a rigid body, first switch off the solver by clicking its green tick in the Object manager. Then move the body as required. Once you are ready to switch on the solver, do not click the solver's red cross (Object manager). This would reset the body to its position before the solver was switched off. Instead, set the new position as the starting state by selecting the Initialize Object function or the Initialize All Objects function from the Plugins > Dynamics menu.

Integration Method

Dynamics must solve a number of complex differential equations in order to calculate the motion of bodies in the dynamics system. The scientific term for this entire calculation is 'integration'. Various integration methods can be used to solve these equations. The Integration Method parameter defines which particular method the solver will use.

Euler

The least accurate but fastest to calculate method. It is about half as accurate but twice as fast at Midpoint. Use this method for simple collision animations where no soft body objects are involved.

Midpoint

Fast to compute, but not very accurate.

Current dynamics engines are unable to solve each and every possible combination of bodies and force fields. Among other things, this may be due to rounding errors or unsolvable equations. In such a case, try adjusting the position of the individual objects, springs and forces. Also, try adjusting the parameters of the springs and force fields.

Runge-Kutta

Generally 10 times more accurate than Midpoint, but four times slower.

Adaptive

The most accurate method; slowest method to process.

Softbody

Use this method if soft bodies are involved. Usually you can set Oversampling to a low value when using this method, such as 2 or 4. The method computes quickly, especially with soft body collisions, and can be as much as 100 times faster than the other methods. (Although some of the other methods are generally fast to compute, they would be slowed down by requiring a much higher Oversampling value than is needed with the Softbody method.)

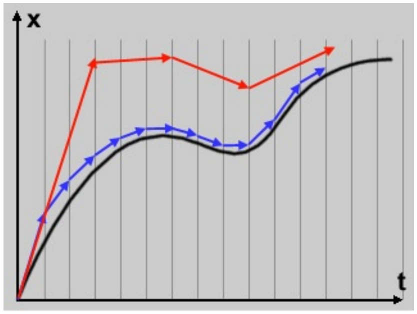
No matter which method you choose, the motion will be approximated to some degree. Your aim when setting the Integration Method and its associated parameters is to find a suitable balance between accuracy and processing time.

Oversampling

For the Midpoint and Runge-Kutta integration methods, the Oversampling value defines the number of times the motion will be integrated per frame. Hence to increase the accuracy of the motion, select a higher Oversampling value. Note that a higher value will increase the processing time.

For the Adaptive integration method, the Oversampling value defines the minimum number of integrations per frame. The actual number will depend on the Subsampling value.

The bottom curve represents the perfect motion. The two other curves use the same integration method, but the middle curve uses a higher Oversampling value, lending it greater accuracy.

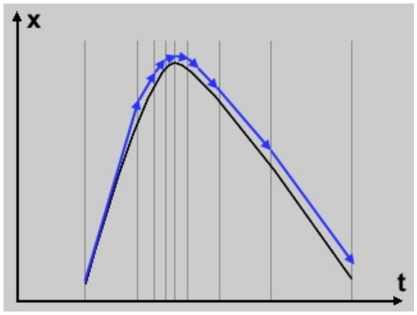


Subsampling

You can define Subsampling for Adaptive integration only. Subsampling works together with Oversampling to define the number of integrations per frame for Adaptive integration. Oversampling defines the minimum number of integrations per frame. The Oversampling value multiplied by the Subsampling value defines the maximum number of integrations per frame.

For example, with Oversampling set to 4 and Subsampling set to 8, there will be a minimum of four integrations per frame and a maximum of 32 integrations per frame. With Oversampling set to 2 and Subsampling set to 4, there will be anywhere from 2 to 8 integrations per frame.

Subsampling concentrates on critical areas of the motion, as illustrated below. The actual number of integrations will vary from frame to frame.



With subsampling enabled, integration is concentrated in key areas of the animation. In the diagram, to start with only oversampling is applied; then, as a critical point in the motion is reached (the peak in the diagram), which might be for example a change in direction, more and more subsampling is applied, up to the maximum selected. Eventually the motion becomes less critical and we go back to oversampling.

It is thanks to Subsampling that Adaptive is the most accurate integration method. With subsampling, integration will be concentrated in the most critical areas.

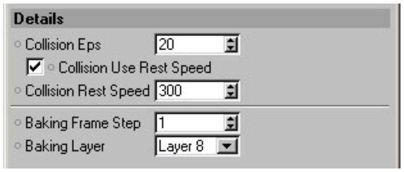
Energy Loss

This parameter is necessary since dynamics engines tend to add energy into the system when the Integration Method is not accurate enough; adding a small energy loss will help to compensate for this slight inaccuracy.

This is similar to real life motion which continually loses energy due to various drag forces. However, if you should notice that, for example, spring oscillations are damped too quickly, reduce the Energy Loss value or the drag or damping within the force object.

Details Tab

Here you'll find settings that relate to collision detection and baking.



Details

Collision Eps 20

☑ Collision Use Rest Speed

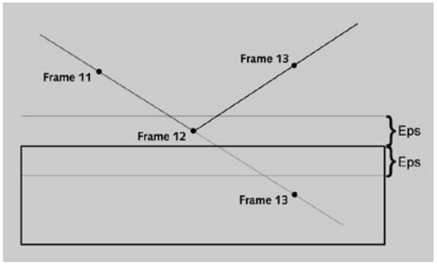
Collision Rest Speed 300

Baking Frame Step 1

Baking Layer Layer 8

Collision Eps (Epsilon)

This parameter is used for collision detection only. It defines a distance in units above and below the surface in which collision can take place, helping to avoid penetration. As soon as an object enters this region, the object will rebound.

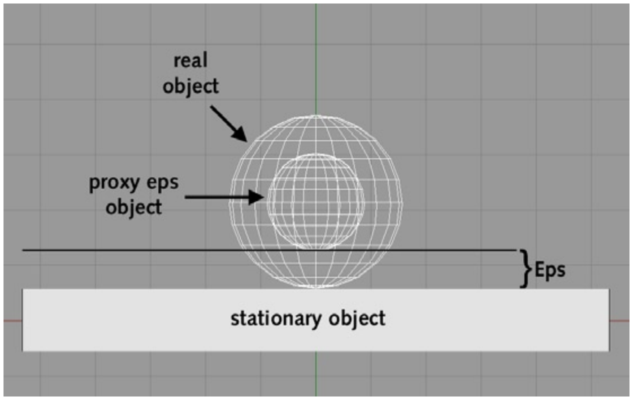


Here, the dots represent the nearest point of an object as the object rebounds off a cuboid. The rebound will take place as soon as the point enters the Eps region.

The Eps parameter is more important that it first appears. It is especially critical when fast-moving objects are colliding with each other. In such cases, the objects will penetrate each other if the Eps value is set too low.

Set the Eps value too high, on the other hand, and objects will rebound before they should. For example, two pool balls may rebound while they are still 10 cm apart if the Eps value is too high. Here, a popular technique can help you to obtain more reliable collisions. It works by making use of a proxy object, using a similar technique to the proxy collision object described in the chapter on rigid bodies. This time, the proxy object should be scaled down so that it is smaller than the real object. This will enable you to use a higher, more reliable, Eps value.

Using a smaller object as a proxy, you can use a higher, more reliable Eps value. The real sphere in the diagram is in the process of rebounding, but it is actually the smaller proxy that has triggered the rebound by entering the Eps region. Without a proxy eps object, a much lower - and therefore less reliable - Eps value would be needed.



Collision Use Rest Speed, Collision Rest Speed

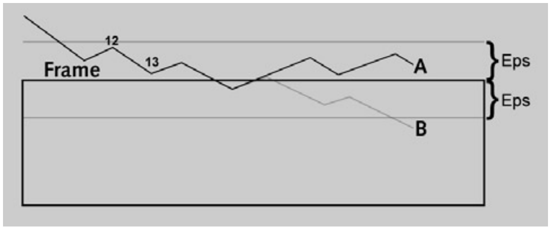
When you slide an object over a surface using Dynamics, under some circumstances, the object may start to 'sink' through the surface.

For an object to rest on a surface, the distance between the object and surface must be less than the Eps distance and the object's velocity must be less than the Collision Rest Speed. Static drag will then take hold.

The Collision Rest Speed parameter is designed to prevent this sinking from happening. When the Use option is enabled, it will give the sliding object a little push away from the surface (in the direction of the surface's normal, that is).

To prevent this little push from being added to rebounding objects that are not sliding, the push will be exerted only if the object's velocity in the direction of the surface is below a certain velocity — this threshold velocity is the Collision Rest Speed.

A . Collision Use Rest Speed enabled. B. Collision Use Rest Speed disabled. The Rest Speed parameter helps to prevent sliding objects from penetrating the surface they are sliding over.



Particularly with complicated spring-mass systems or soft bodies, an inappropriate integration method can create unexpected behavior. This unusual behavior is possible in all existing dynamics engines.

Also possible are instable states with which no realistic motion can be achieved regardless of the integration settings. Such states can be tackled only by using a new spring arrangement or by adjusting the masses, spring forces and damping.

Baking Frame Step

Here you determine how many keyframes will be created when you bake the motion in the Timeline. The most accurate setting here is 1, which will cause a keyframe to be created for each frame. If you intend to edit the animation, you should choose the highest value possible that does not lead to errors with the motion.

If strange results occur such as an increased height of swing, this is likely to be because extra energy is entering the system. Typically, this is caused by an integration method that is too inaccurate or parameters that are set too low. In this case it is always an idea to try adding some extra energy loss, or increasing the solver accuracy.

Baking Layer

CINEMA 4D's timeline has eight layers. For this parameter, select the layer in which the baked track will be placed when you bake the motion in the Timeline. For details on the Timeline's layers, please consult your CINEMA 4D Reference Manual.

Rigid Bodies

Objects that are moving in the dynamics system should be defined as rigid bodies if they don't change their shape, such as pool or snooker balls bouncing off each other and the cushions. In this chapter, you'll learn how to create and use rigid bodies.

A rigid body is a polygon object in the dynamics system whose shape stays the same all the time. It can be given a mass, a starting velocity and aerodynamic properties. In addition, rigid bodies are able to collide with one another. Rigid bodies consist of a single centre of mass that enables them to be rotated around this point during the dynamics animation. In contrast, a soft body is built from many masses each located at the points of the soft body object and so have no initial values for rotation and hence cannot rotate when animated other then through their interactions with other objects.

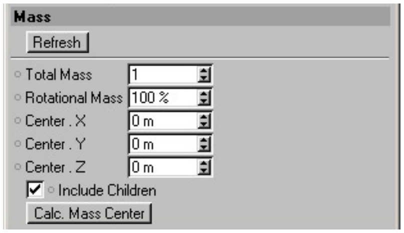
When deciding whether an object should be a rigid body or a soft body, consider whether the object's shape will change during the animation. If the object's shape will stay the same throughout the animation, the object should be a rigid body; otherwise, the object should be a soft body. If you can use a rigid body instead it will greatly speed up your animation. Only use a soft body if really needed, such as for cloth blown by wind.

Rigid Body Dynamic Tag

To define a polygon object as a rigid body, you must give the object a Rigid Body Dynamic tag. To do this, first select the object by clicking its name in the Object manager. Next, in the Object manager, select File > Dynamics Tags > Rigid Body Dynamic. The Rigid Body Dynamic settings will appear in the Attribute manager. These parameters are described below, tab by tab.

Mass Tab

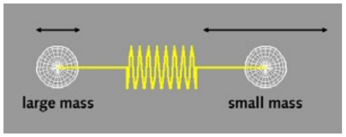
Double-click the Rigid Body Dynamic tag to display its settings in the Attribute manager.


Mass
Refresh
Total Mass 1
Rotational Mass 100 %
Center . X 0 m
Center . Y 0 m
Center . Z 0 m
[✓] Include Children
Calc. Mass Center

Total Mass

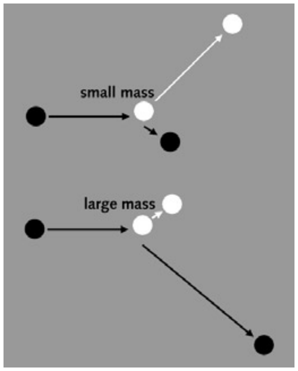
Here, set the mass of the rigid body. The Total Mass will always play a role when the body interacts with other rigid bodies. This applies to collision detection, gravity fields, wind, drag and rigid bodies attached via springs.

The higher the Total Mass value, the greater the force that the body will exert on the interacting objects.



The spring pulls both spheres with the same force giving a higher acceleration to the right sphere, making it oscillate more.

In the diagram above, two spherical rigid bodies are attached via a spring. Note how the smaller mass is oscillating over a greater distance. This is because the left sphere has a large mass, which in turn needs a higher force to give it the same acceleration. The spring pulls both spheres with the same force giving a higher acceleration to the right sphere, making it oscillate more.



Two cases of a black sphere shooting into a white sphere that is initially at rest.

Above you can see two cases of a black sphere shooting into a white sphere that is initially at rest. In the first case, the white sphere has a smaller mass than the incoming black sphere and hence it is moving rapidly after the collision. In the second case, however, the white sphere has a larger mass and so the black sphere makes little impact on the sphere during the collision making it move slowly after the collision.

To summarize these two diagrams:

Forces being equal, a small mass will be accelerated more and tend to move faster than a larger mass.

The greater the mass, the greater the force required to achieve the same acceleration.

When two objects of different mass collide, the smaller mass will be affected most.

If, on the other hand, you set the Total Mass to 0, the following will apply:

The dynamics engine will exert no force on the rigid body.

You will be able to animate the rigid body using keyframes in the Timeline, even if the rigid body is attached to another rigid body via a spring.

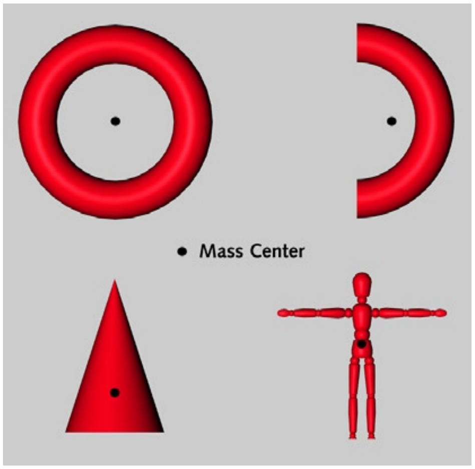
Rotational Mass

This parameter enables you to fine-tune the rotational behavior of the rigid body. The value is specified as a percentage of the Total Mass value. The higher this Total Mass value then the greater the force that will be required to change the rotation of the rigid body.

Center

These three input boxes define the X,Y,Z position of the mass centre in relation to the origin. It is an offset. To move the centre of mass, enter the desired offset.

Each rigid body has a mass centre. By default, the mass centre will be in the same position as the rigid body's origin. The Center parameters enable you to change the position of the centre of mass, which is displayed in the viewport as a yellow cross.



The mass centres of various objects.

If a force is exerted on the centre of mass, the rigid body will experience linear acceleration only in the direction of the force. If the force is instead exerted on a point away from the centre of mass, such as may happen during a collision, the rigid body will experience angular as well as linear acceleration, which will cause it to rotate as well as move.

The centre of mass is also used to determine whether the rigid body is inside a field. The force will be exerted only if the centre of mass is inside the field.

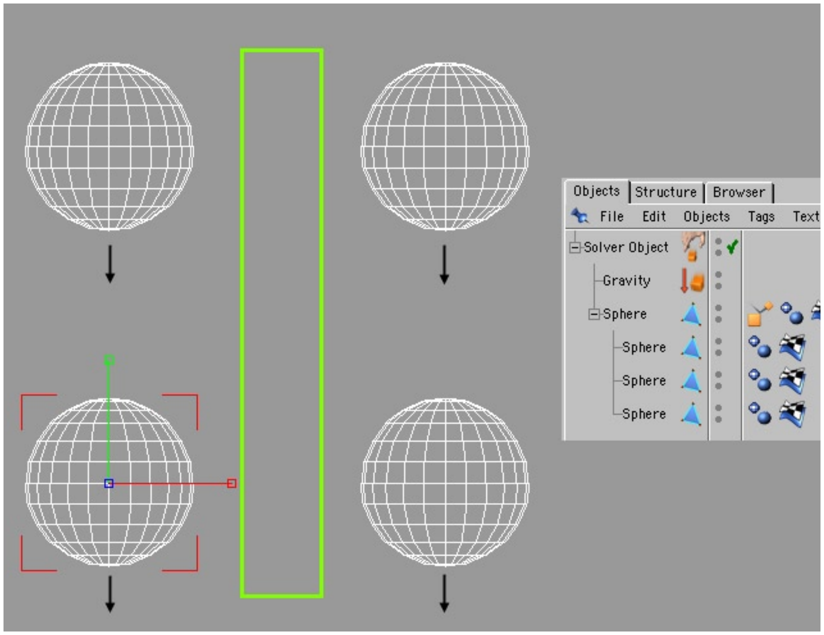
Lastly, a rigid body attached to an angular spring or used with a constraint will rotate about its centre of mass.

Calc. Mass Center

If you click this button, the centre of mass will be calculated based on the points of the rigid body.

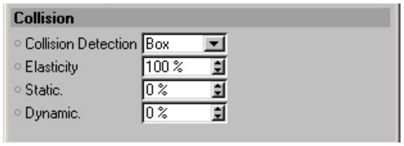
Include Children

If the rigid body has children, you will usually want the children to move along with the rigid body without having to create a Rigid Body Dynamic tag for each child. If you enable this option, the Mass Center will be calculated for the entire hierarchy.



A sphere with three other spheres as children. With the Include Children option enabled, the entire hierarchy will fall downwards when the parent sphere enters the gravity field.

Collision Tab



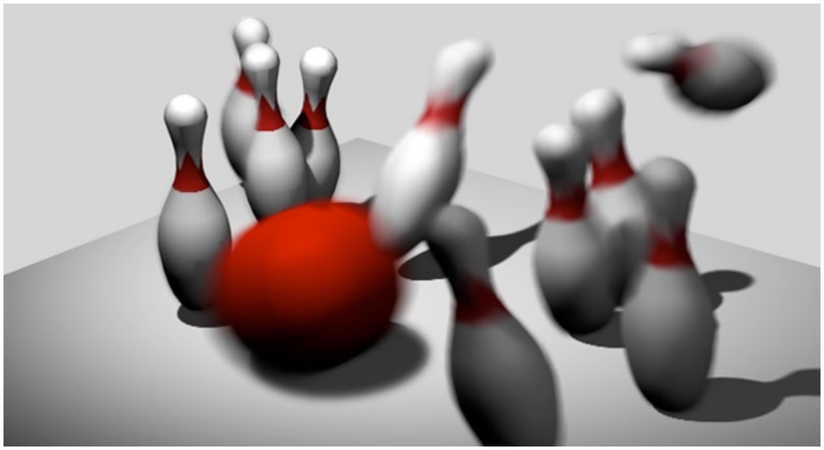
Collision

Collision Detection	Box
Elasticity	100 %
Static.	0 %
Dynamic.	0 %

Collision detection is one of the major features of Dynamics. However, many types of collisions can be simulated using force fields instead, which can be much faster to compute!

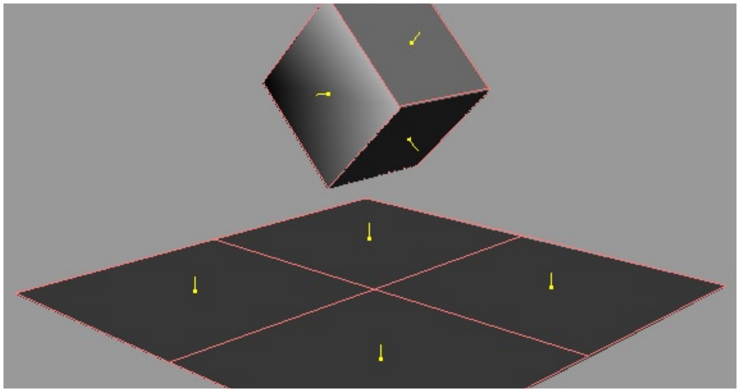
Collision detection — one of the main features of Dynamics — prevents colliding bodies from penetrating each other. Instead the bodies will be made to bounce off each other or slide along each other, just as if they were real solid objects.

Using the parameters on this tab you can enable or disable collision detection for the rigid body as well as adjust its collision properties such as the elasticity of the collision, that is how much energy is lost during the collision, a perfectly elastic (100%) collision will lose no energy.


Simulating a strike using keyframes would be a tiresome exercise. With collision detection, Dynamics will calculate these complex collisions for you.

When animating using collision detection it is vital that none of your objects with collision detection enabled are penetrating each other at the start of the animation, or collision detection will fail. The Console will aid you here by displaying an error message if bodies are inside each other. To open the Console, select Window > Console from the main menu.

Also, check that the surface normals of the colliding objects are facing each other. If they are not, collision detection will be unable to find a suitable solution and will also fail.


The surface normals of colliding objects must be facing each other for collision detection to function correctly. Here, the surface normals of two bodies are facing each other as required.

Collision Detection

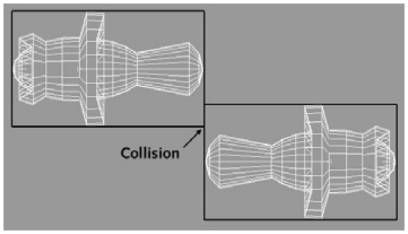
Here you can select from three types of collision detection or switch off collision detection.

None

Switches off collision detection. This is the default setting.

Box

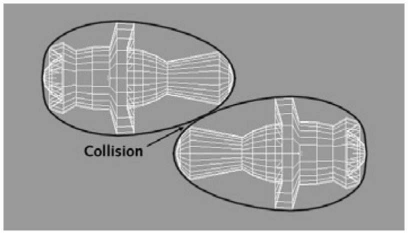
Encloses the object in a box. Collision will take place when this box hits other objects. This is the fastest type of collision to calculate.



With Box collision detection, a box is placed around the object. Collision will take place when this box collides with another rigid body.

Ellipsoid

This is a more accurate type of detection than Box for many spherical type shapes, but it takes longer to calculate. You will find a proxy object in the shape of your surface with as fewer polygons as possible will be the best overall solution to good and fast collision detection.

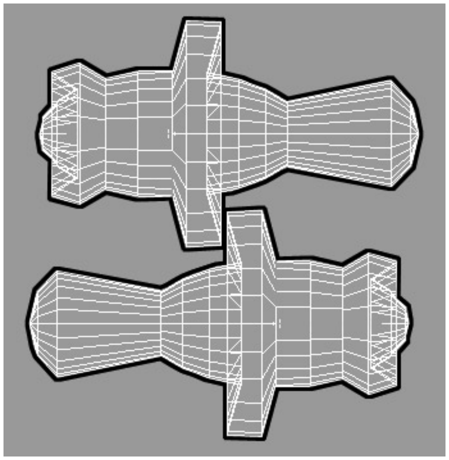


Two objects with Collision Detection set to Ellipsoid, a more accurate type of detection than Box.

Full

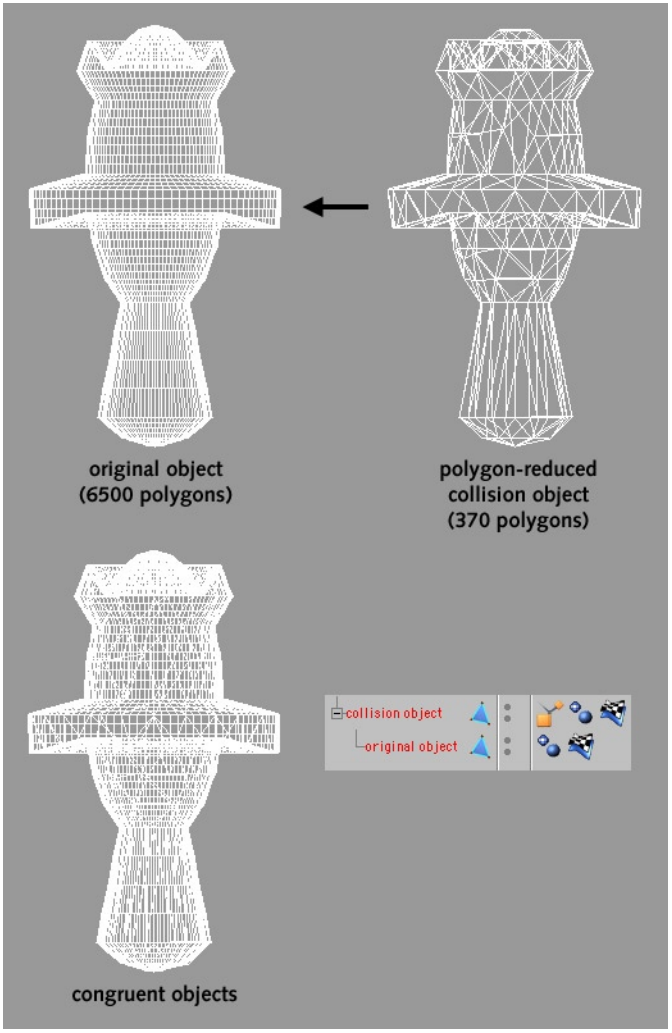
With Full, each polygon will be checked for collision. Full is by far the most accurate type of collision detection but it also takes much longer to process than Box and Ellipsoid.

Full collision detection means collision detection at the polygon level.



You can, however, greatly reduce the processing time by using a proxy collision object. These can then use the Full collision to give accurate collisions while maintaining some speed due to the simple nature of the proxy objects polygon geometry.

Using a proxy collision object can save an enormous amount of processing time while keeping the detection accurate.



To create a proxy collision object:

Create the object that will act as the proxy collision object by copying the source object. Use the PolyReduction tool to reduce the proxy. The proxy in the diagram has been reduced from 6500 polygons to 370 polygons.

Ensure that the source object and proxy object are more or less the same shape.

Make the source object a child of the proxy object.

Set up collision detection using the proxy object instead of the source object.

The collision detection will now be processed in a fraction of the usual time. In the case of the diagram example, 370 polygons will now be checked instead of 6500.

Elasticity

This value defines the percentage of energy that the rigid body will retain following a collision. An Elasticity setting of 0% would cause the rigid body to halt suddenly during the collision while a value of 100% would see the rigid body rebound without loss of speed.

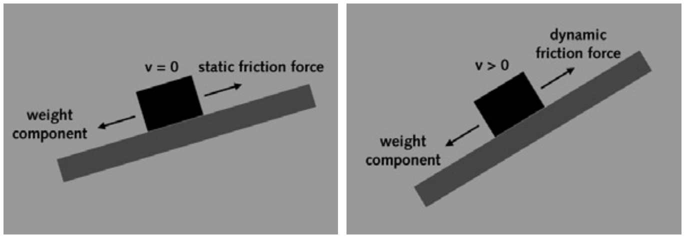
For example, in the case of a pool table, the pool balls should have an elasticity closer to 100% than to 0% since pool balls keep most of their velocity following a collision.

Static, Dynamic

When two bodies are in contact, a type of friction will exist between the bodies. If the bodies are at rest relative to each other, the friction will be static and will resist any motion between the two bodies, this is the friction we mostly notice during everyday life. If the bodies are moving relative to one another, the friction will be dynamic and try and slow the bodies by transferring the movement to heat.

Both types of friction can be simulated with Dynamics.

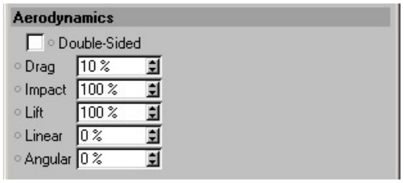
Static friction is always greater than dynamic friction. For example, when trying to push a car that has broken down it is harder to get the car moving than it is to keep it moving.



On the left, the block's weight component down the incline is not great enough to overcome 'static' friction, so the block does not slide.
On the right, the incline has been increased and the block is now sliding. Static friction having been overcome, the block is now being resisted instead by the lesser force of 'dynamic' friction.

Aerodynamics Tab

Note that the Wind field contains similar parameters (with the exception of Double-Sided). The parameters in the Wind field set the general aerodynamics behavior while the parameters here are used to fine-tune the aerodynamics for the rigid body.


Aerodynamics

☐ Double-Sided

Drag 10 %

Impact 100 %

Lift 100 %

Linear 0 %

Angular 0 %

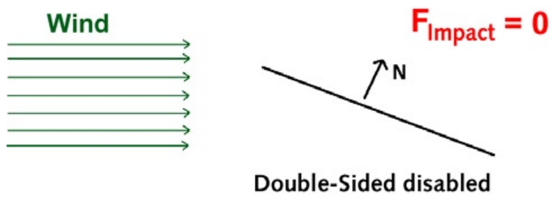
You can use this tab's parameters to modify the aerodynamic behavior of the rigid body. The parameters here will be multiplied with those in the Wind field. For example, if you have set Impact to 50% in the Rigid Body Dynamic tag's settings and 80% in the Wind field, the resulting value for the rigid body will be 40%.

Suppose you have 20 rigid bodies inside a Wind field. The wind settings are working well for 19 of the rigid bodies but the other rigid body is not moving as it should. If you try to correct the flight of this one rigid body by adjusting the parameters in the Wind field, you might find that doing this would ruin the flight of the other 19 rigid bodies. A better solution is to modify the parameters on the Aerodynamics tab of the rogue rigid body.

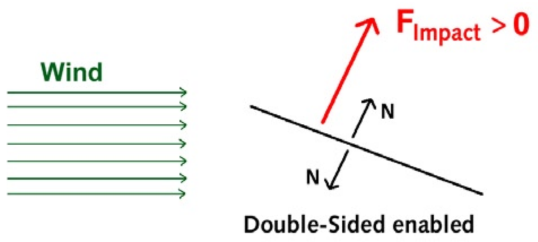
Double-Sided

If this option is disabled — the default setting — the wind will affect only those polygons whose surface normals are facing the wind. If you enable the option, the wind will exert its force on all polygons regardless of the direction in which their surface normals are pointing. Only enable the Double-Sided option if your object has no thickness and Lift is set to 0%.

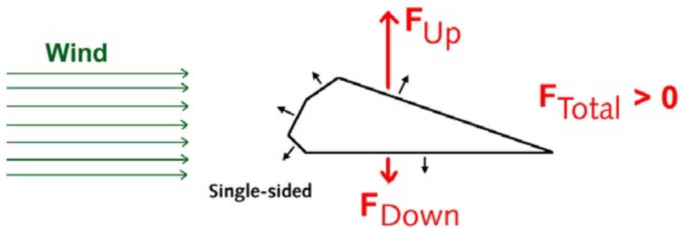
Double-Sided disabled. Since the normal is facing away from the wind, the wind is unable to exert a force on the surface.



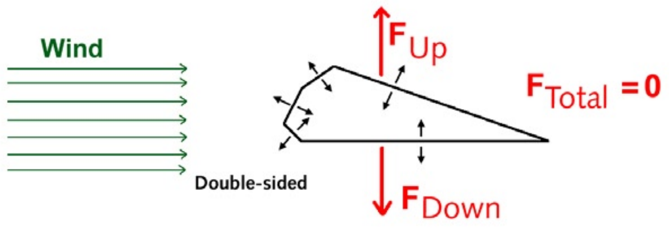
Double-Sided enabled. This guarantees that a normal will face the wind and hence the wind is now able to exert a force on the surface.



Double-Sided disabled. The wing is experiencing a lifting force.



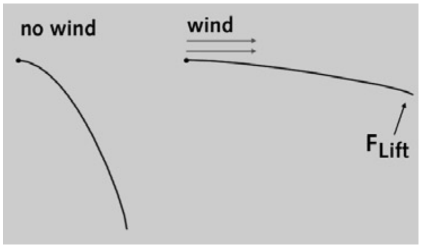
Double-Sided enabled, causing equal and opposite forces for each surface and hence no resultant force. For this reason, Double-Sided should be disabled for closed polygons.



Lift

This setting defines the strength of lift. When an airstream passes over a surface, the air pressure will drop. The faster this airstream, the lower the pressure. When designing a wing, the wing must be shaped so that the air stream will pass over one wing surface more quickly than over the other wing surface. This will create a pressure gradient, causing the wing to experience a lifting force.

If you were to hold out a piece of paper and blow along its top edge, the airstream would create lift — as the air passes over the paper, it lifts up the sheet until the pressure is equal on both sides of the paper.



A practical example of lift. Blow across a hanging piece of paper and the airstream will create a lifting force that will move the paper into line with the airstream.

Occasionally, paradoxical situations may arise such as motion that heads into the wind. In such cases you should reduce the lift in one of two places. You can reduce the parameter either in the Wind field (Lift Coeff.) or the Rigid Body Dynamic dialog (Lift). The latter is usually preferable since it enables you to adjust the lift for a uncooperative object without affecting the flight of the other objects.

Impact

The Impact value determines the strength of the air force that will be exerted on body surfaces that face the wind. The strength of the impact force is proportional to the surface area facing the wind and the relative velocity of the body compared to the wind.

Drag

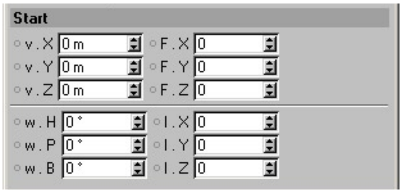
When air streams over a body, small eddies will beat against the body's surfaces, causing deceleration. The Drag parameter defines the strength of this effect. This decelerating effect is usually minor but occasionally it can have a telling influence on the object's motion.

Linear, Angular

These settings work with the Linear Coeff. and Angular Coeff. settings for the Wind field. For details on these settings, look up "Linear Coeff., Angular Coeff." in the index.

Start Tab

The values entered into the Start tab will give an object an initial state for the dynamics to work on.



Start

v.X	0 m	F.X	0
v.Y	0 m	F.Y	0
v.Z	0 m	F.Z	0
w.H	0°	I.X	0
w.P	0°	I.Y	0
w.B	0°	I.Z	0

The Start tab enables you to define the state of the rigid body at the start of the dynamics animation, such as the rigid body's starting velocity.

The 'v' settings define the starting velocity of the rigid body. The 'w' settings set the angular velocity (rotation). 'F' defines a force that is exerted during the first frame of the dynamics animation. The values you enter for 'I' will define the torque applied during the first frame of the dynamics animation.

Rigid Body Spring Tag

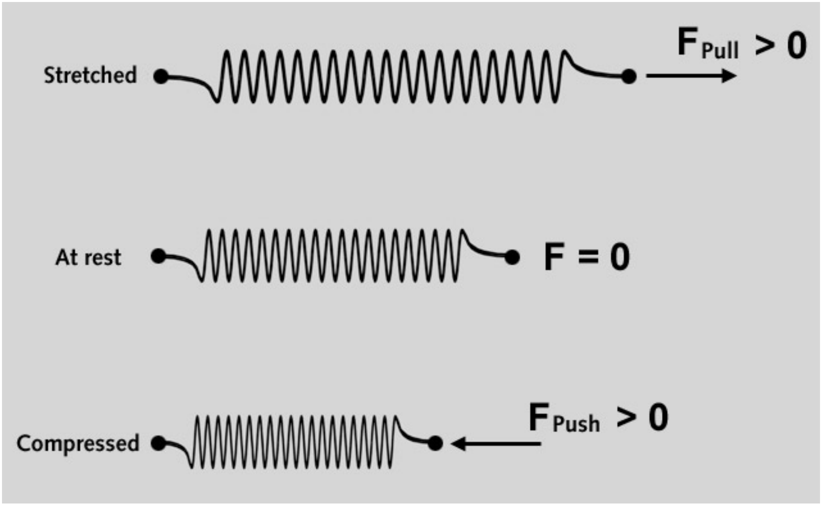
Springs enable you to attach polygon objects to one another. Springs can be attached to any object point and you can attach more than one spring to the same object.

To access the Rigid Springs dialog at any time, double-click the tag's icon in the Object manager.

To create rigid body springs, you first need to assign a Rigid Body Spring tag to the Solver object. To do this, select the Solver object by clicking its name in the Object manager. Next, select File > Dynamics Tags > Rigid Body Spring from the Object manager's menu. This will assign the tag to the solver and at the same time the Rigid Springs dialog will open. Using this dialog, you can create all the required springs and for each spring you can define its characteristics such as its rest length and its damping.

Imagine yourself pulling a spring then letting go. Once you let go, the spring will return to its original length then compress, extend back out again, compress once more and continue to oscillate in this way until it eventually comes to rest at its normal length. While the spring is oscillating, it is undergoing elastic deformation, meaning that the spring will eventually return to its original shape once all force has been removed.

Underlying elastic deformation is one important law of physics. Provided a spring is within its elastic deformation range, the length of the spring's extension is directly proportional to the force exerted on the spring. So if a force of 10 Newtons stretches a spring by 5 cm, a force of 20 Newtons will stretch the spring by 10 cm.



Provided a spring is within its elastic deformation range, the length of the spring's extension is directly proportional to the force exerted on the spring.

Now suppose you pull the spring a second time, only this time you pull much harder. So much harder, in fact, that the spring is permanently distorted. When you let go, the spring will not return to its original length. The spring has undergone plastic deformation, which occurs once the spring has been stretched beyond a point known as the spring's elastic limit.

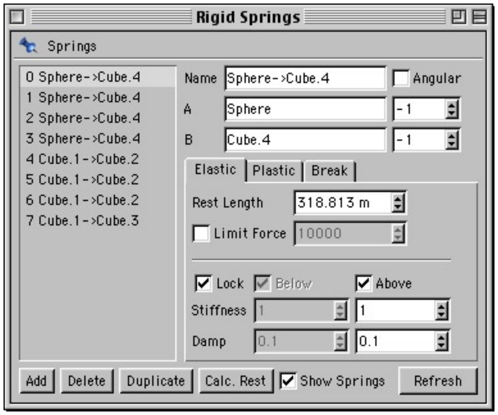
Now you pull the spring once more, only this time with all your might. So you give a Herculean tug and ... the spring snaps of course.

All of this behavior — snapping, plastic deformation and elastic deformation — can be simulated using the springs in Dynamics. Note that springs are displayed yellow in the viewport when not selected.

There are two ways to create springs and attach them to rigid bodies. Either the springs can be created using the Rigid Springs dialog or the springs can be drawn in the viewport using the RBS Draw Tool.

Using the Rigid Springs Dialog

Create, edit and attach springs in the Rigid Springs dialog.


Rigid Springs

Springs

0 Sphere->Cube.4
1 Sphere->Cube.4
2 Sphere->Cube.4
3 Sphere->Cube.4
4 Cube.1->Cube.2
5 Cube.1->Cube.2
6 Cube.1->Cube.2
7 Cube.1->Cube.3

Name: Sphere->Cube.4 ☐ Angular
A: Sphere, -1
B: Cube.4, -1

Elastic | Plastic | Break

Rest Length: 318.813 m
☐ Limit Force: 10000

✓ Lock ✓ Below ✓ Above
Stiffness: 1 | 1
Damp: 0.1 | 0.1

Using the Rigid Springs dialog, you can create, edit and attach springs as well as adjust all of the properties of the springs including elastic and plastic behavior.

You can select and edit multiple springs. To add a spring to the selection, Ctrl-click the spring's name or number in the spring list. To remove a spring from the selection, Ctrl-click once more.

If the settings of the selected springs differ — e.g. if one spring has a Rest Length of 50 and another a Rest Length of 30 — the parameter boxes that hold the differing values will be highlighted with a bright color. You will still be able to enter new values using these highlighted parameters. The highlighting is simply to make you aware that the corresponding values currently differ for the selected springs.

When you change a setting, the new setting will be applied to all of the selected springs, regardless of whether the parameter was highlighted or not. If you need to specify an individual parameter for a spring, you must select that spring only and edit it separately.

Name

You can optionally type in a name for the spring.

Add, A, B

The Add button creates a spring. The spring will appear in the spring list, which is the large region in the left half of the dialog.

To find out the point's number, ensure the rigid body is selected in the Object manager (click on its name). Select the Points tool, then select the point in question. Now, open the Structure manager (main menu: Window > Structure Manager). Ensure the Points mode is active (Structure manager: Mode > Points). The point's number will be highlighted under the Point column.

Having created a spring using Add, you need to define which rigid bodies the spring should be attached to. To do this, enter the names of the rigid bodies under A and B. You must type in the names exactly as they appear in the Object manager. To the right of A and B input boxes are two further input boxes. Use these to define two points of the rigid bodies to which the spring should be attached. The default value of -1 will attach the spring to the mass centre. To change this, enter the point's number.

Angular

Enable this option if you want to define the spring as an angular spring. In this case you should enter the name of the rigid body under A.

Delete

Deletes the spring that is currently selected in the spring list.

Duplicate

Duplicates the spring that is currently selected in the spring list.

Calc. Rest

Sets the Rest Length value to the spring's current length. This is useful after you have attached the spring to two rigid bodies since it will set the Rest Length accordingly.

Show Springs

Controls whether springs are displayed in the viewport.

Refresh

Forces a refresh of the viewport, causing the springs to be redrawn. For example, if you have just attached a spring between two points, clicking Refresh will make the spring appear in the viewport. The viewport will refresh the springs automatically when you select another spring or when you move the camera.

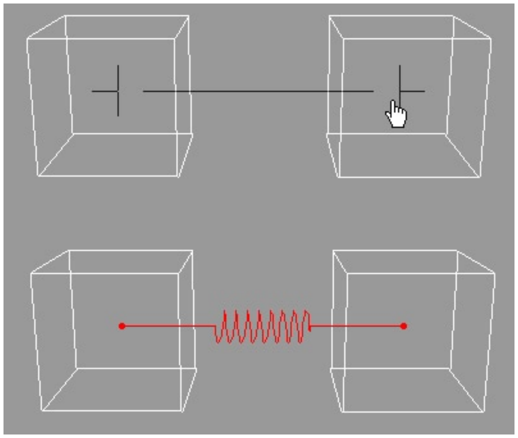
Using the RBS Draw Tool

Although you can create and attach springs using the Rigid Springs dialog, the RBS Draw Tool is preferred in most cases because it enables you to draw the springs interactively in the viewport.

Springs that you create using the RBS Draw Tool will still appear in the Rigid Springs dialog. Hence you will be able to edit the spring parameters such as elastic and plastic behavior later using the dialog.

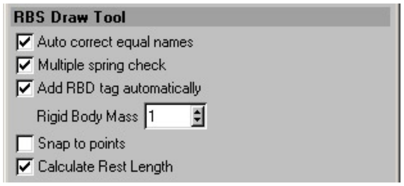
Before you create the springs, first ensure that you have assigned a Rigid Body Spring tag to the Solver object (File > Dynamics Tags > Rigid Body Spring Tag in the Object manager menu). Ensure also that the rigid bodies are children of this Solver object. Next, select the RBS Draw Tool (Plugins > Dynamics > RBS Draw Tool in the main menu).

To draw the spring, drag from the first rigid body to the second rigid body. As you drag, a cross will appear where you first started dragging and a second cross will appear once the mouse pointer is in a suitable position over the second rigid body. When you release the mouse button, the spring will be created and placed between the two crosses.


Using the RBS Draw Tool, you can create and attach springs interactively in the viewport. Two crosses will appear while you draw to indicate the attachment points.

Attribute manager settings

While the RBS Draw Tool is selected, a number of options will be available in the Attribute manager.


RBS Draw Tool
[✓] Auto correct equal names
[✓] Multiple spring check
[✓] Add RBD tag automatically
Rigid Body Mass 1
[ ] Snap to points
[✓] Calculate Rest Length

While the RBS Draw Tool is selected, a number of options will be available in the Attribute manager, including the ability to snap to points.

Auto Correct Equal Names

This option is enabled by default. If you draw a spring between two rigid bodies with the option enabled, the names of the rigid bodies will be changed automatically to ensure they are unique within the scope of the solver. For example, assuming there are three rigid bodies in the solver all named Cube, when you draw a spring between two of the bodies, they will be renamed Cube.1 and Cube.2. This automatic renaming is advisable so that, when you later use the Rigid Springs dialog, it will be clear to which objects each spring is attached.

Multiple Spring Check

When enabled, this option will prevent you from creating a spring where a spring already exists between the two points.

Add RDB Tag Automatically, Rigid Body Mass

If this option is enabled when you draw a spring, Rigid Body Dynamic tags will be assigned to the two objects that the spring is being attached to. The mass defined under Rigid Body Mass will be assigned to the tags. The tags will not be created if the objects already have Rigid Body Dynamic tags assigned.

Snap to Points

Enable this option if you want the cursor to snap to object points while you are drawing the spring. If the option is disabled, the spring will snap to the mass centre of the objects instead.

Calculate Rest Length

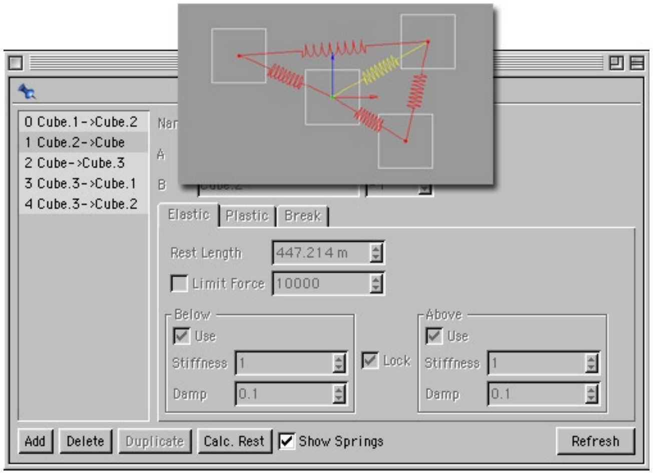
If Calculate Rest Length is enabled while you are drawing a spring, the Rest Length of the spring will be set to the distance between its two attachment points. In other words, the spring will be at rest between the two points, hence the spring will exert no force.

Using the Rigid Body Selection Tool

This tool is used for selecting springs in the viewport. To add a spring to the selection, Shift-click the spring with the tool selected. To remove a spring from the selection, Ctrl-click the spring. Selected springs are displayed red in the viewport. Selection in the viewport is linked to selection in the spring list in the Rigid Springs dialog; in other words, selecting springs in the viewport automatically selects them in the spring list also and vice versa.

Spring selection: selection in the viewport is linked to selection in the Rigid Body Spring dialog.

You can also select springs without using the Rigid Body Selection tool. Simply click the spring in the viewport to select it. To add the spring to the selection, Shift-click the spring. To remove a spring from the selection, Ctrl-click the spring.


0 Cube.1->Cube.2
1 Cube.2->Cube
2 Cube->Cube.3
3 Cube.3->Cube.1
4 Cube.3->Cube.2

Elastic | Plastic | Break

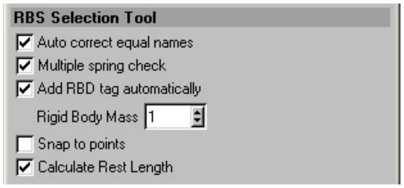
Rest Length 447.214 m
☐ Limit Force 10000

Below: ✓ Use; Stiffness 1; Damp 0.1
✓ Lock
Above: ✓ Use; Stiffness 1; Damp 0.1

In addition to allowing you to select springs, the Rigid Body Selection tool also lets you re-attach springs in different positions. To do this, click-drag the end of the spring that you want to re-attach from the old position to the new position.

Attribute manager settings

While the RBS Selection Tool is selected, a number of options will be available in the Attribute manager.


RBS Selection Tool
- ✓ Auto correct equal names
- ✓ Multiple spring check
- ✓ Add RBD tag automatically
- Rigid Body Mass 1
- ☐ Snap to points
- ✓ Calculate Rest Length

While the RBS Selection Tool is selected, a number of options will be available in the Attribute manager, including the ability to snap to points.

Auto Correct Equal Names

This option is enabled by default. If you draw a spring between two rigid bodies with the option enabled, the names of the rigid bodies will be changed automatically to ensure they are unique within the scope of the solver. For example, assuming there are three rigid bodies in the solver all named Cube, when you draw a spring between two of the bodies, they will be renamed Cube.1 and Cube.2. This automatic renaming is advisable so that, when you later use the Rigid Springs dialog, it will be clear to which objects each spring is attached.

Multiple Spring Check

When enabled, this option will prevent you from creating a spring where a spring already exists between the two points.

Add RDB Tag Automatically, Rigid Body Mass

If this option is enabled when you draw a spring, Rigid Body Dynamic tags will be assigned to the two objects that the spring is being attached to. The mass defined under Rigid Body Mass will be assigned to the tags. The tags will not be created if the objects already have Rigid Body Dynamic tags assigned.

Snap to Points

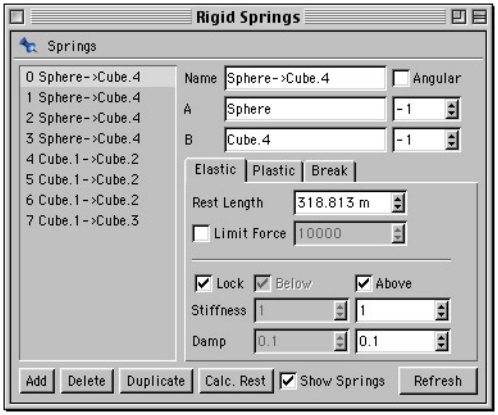
Enable this option if you want the cursor to snap to object points while you are drawing the spring. If the option is disabled, the spring will snap to the mass centre of the objects instead.

Calculate Rest Length

If Calculate Rest Length is enabled while you are drawing a spring, the Rest Length of the spring will be set to the distance between its two attachment points. In other words, the spring will be at rest between the two points, hence the spring will exert no force.

Elastic Tab

The options on this tab enable you to define the elastic properties of the rigid body spring.



Rigid Springs

Springs

0 Sphere->Cube.4
1 Sphere->Cube.4
2 Sphere->Cube.4
3 Sphere->Cube.4
4 Cube.1->Cube.2
5 Cube.1->Cube.2
6 Cube.1->Cube.2
7 Cube.1->Cube.3

Name: Sphere->Cube.4 ☐ Angular
A: Sphere, -1
B: Cube.4, -1

Elastic | Plastic | Break

Rest Length: 318.813 m
☐ Limit Force: 10000

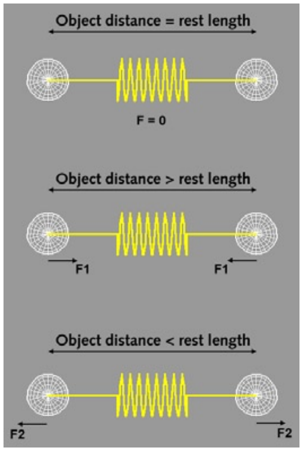
☑ Lock ☑ Below ☑ Above
Stiffness: 1 | 1
Damp: 0.1 | 0.1

Add | Delete | Duplicate | Calc. Rest | ☑ Show Springs | Refresh

Rest Length

The Rest Length defines the normal length of the spring, that is the length at which the spring will exert no force. In the diagram below, the top spring is at its rest length and hence it is exerting no force on the objects.

The Rest Length is decisive in determining whether the spring will push, pull or exert no force on its attached objects.


Object distance = rest length
F = 0
Object distance > rest length
F1
F1
Object distance < rest length
F2
F2

If you were to attach two objects using a spring whose Rest Length value is less than the distance between the two objects, the spring will be stretched because of this and it will exert a force on the two bodies that will attempt to pull them towards the rest length. Conversely, if the Rest Length value is greater than the distance between the two attached objects, the spring will be compressed because of this and will exert a force on the two objects that attempts to push them away from one another and towards the rest length.

Limit Force

In some cases, the force exerted by a spring can become too great for the solver object to process. Hence under Limit Force you can specify the maximum force that the spring will be allowed to exert.

Lock

If enabled, this option will lock the Below values to be the same as the Above values.

Below

This option and the Stiffness and Damp parameters below it define the spring's behavior when the spring is below its rest length (i.e. compressed). By default, these settings are ghosted by the Lock option, which locks the Below parameters to the same settings as the Above parameters. To be able to define separate values for compression, disable the Lock option.

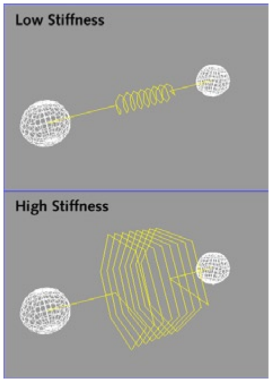
Above

This value refers to the spring when it is above its rest length (stretched, that is). If Above is enabled, the Stiffness and Damp values will be applied while the spring is stretched. With the option disabled, the spring will be limp when stretched and it will thus exert no force.

Stiffness

These two input boxes define the stiffness of the spring for the Below and Above options. The higher the value, the greater the force that will be exerted by the spring when it is stretched or compressed. A stiff spring will be much harder to compress or stretch than a weak spring.

A spring's Stiffness affects its diameter in the viewport.

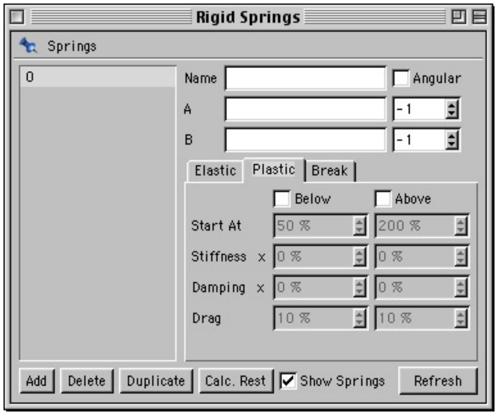


The Stiffness value of the spring is indicated in the viewport. The stiffer the spring, the greater its diameter. The Stiffness also affects the spring's rate of oscillation, with a stiff spring tending to oscillate faster than a weak spring because of the greater force that it exerts on the objects it is attached to. The time taken for an oscillation in such a spring-mass system will also depend on the mass of the attached objects.

Damp

Like Stiffness, there are two input boxes. The left-hand input box defines the damping for the Below option; the right-hand input box defines damping for the Above option. All real springs will experience damping while oscillating due to resistance within their material. Without damping, a spring would oscillate endlessly. For realistic damping, set a value from 0.1 to 0.5.

Plastic Tab

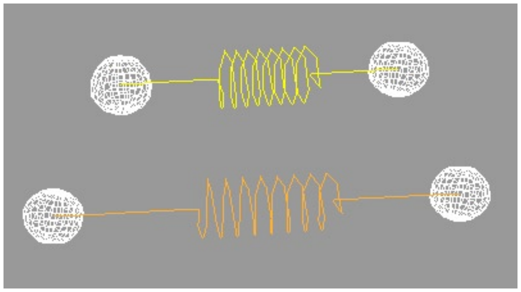


	☐ Below	☐ Above
Start At	50 %	200 %
Stiffness x	0 %	0 %
Damping x	0 %	0 %
Drag	10 %	10 %

☐ Angular ☑ Show Springs

The options on the Plastic tab enable you to define at what point a rigid body spring will remain deformed.

When you stretch a spring past its elastic limit, the spring will become permanently distorted — termed plastic deformation. On this tab, you can set the parameters that will simulate plastic deformation for your virtual spring.



Above: A spring in the elastic state.

Below: The same spring, this time in the plastic state. Springs in the plastic state are shaded orange in the viewport.

Using Below and Above, you can define the plastic properties of the spring when stretched and compressed. Keep in mind that a spring's stiffness and damping will change greatly between elastic deformation and plastic deformation.

Below

Enable this option if you want to define the plastic properties of the spring (Start At, Stiffness X, Damping X, Drag) when it is below its rest length (compressed, that is).

Above

When Above is enabled, you will be able to define the plastic properties of the spring (Start At, Stiffness X, Damping X, Drag) when it is above its rest length (stretched, that is).

Start At

This defines the length at which plastic deformation will begin, specified as a percentage of the Rest Length (Elastic tab). For example, if you enter a value of 200% and Rest Length = 10 m, plastic deformation will start when the spring is 20 m long.

Stiffness X

Use Stiffness X to set the stiffness of the spring for plastic deformation. The value must be defined as a percentage of Stiffness (Elastic tab). For example, if you enter a Stiffness X value of 10% and Stiffness = 5, the stiffness of the spring during its elastic state will be 0.5.

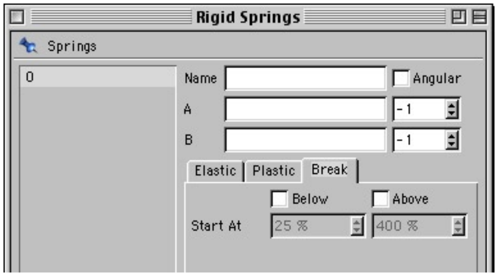
Damping X

Damping X controls the strength of damping for the plastic state, defined as a percentage of Damp (Elastic tab). For example, with Damping X set to 50% and Damp set to 0.1, the damping during the plastic state will be 0.05.

Drag

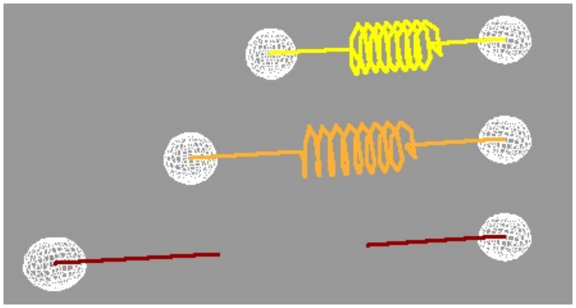
This setting will ensure that the attached objects are damped while the spring is undergoing plastic deformation. This can be thought of as a drag field that affects the two attached objects only.

Break Tab



The options on the Break tab define at what point a rigid body spring will lose all of its properties — literally break.

Like a real spring, Dynamics springs can be made to snap if you stretch them too far. Before a real spring snaps, it will first undergo elastic deformation followed by plastic deformation.


The sequence of events leading to snapping: elastic deformation (top), plastic deformation (middle), snapping (below). A broken spring is shaded red in the viewport.

Once the spring has been broken, just as in real life it won't be able to exert a force on the attached objects any more.

Below

Enable this option to allow the spring to break when compressed. Define the breaking point using the Start At parameter.

Above

Enable this option if the spring should break when stretched. Define the breaking point using the Start At parameter.

For snapping to be possible, the spring must have its plastic state defined — that is, Below and/or Above must be enabled on the Plastic tab. However, you can, if you wish, still have the spring snap without it first having to undergo plastic deformation: set the Start At parameters on the Plastic tab and the Break tab to the same value.

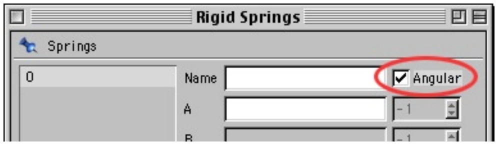
Start At

These two input boxes set the breaking point for the Below option (left-hand input box) and the Above option (right-hand input box). Into the input boxes, enter the breaking point as a percentage of the Rest Length (Elastic tab). For example, if Start At is set to 300% and Rest Length is set to 200 m, the spring will snap once it reaches 600 meters in length.

Angular Springs

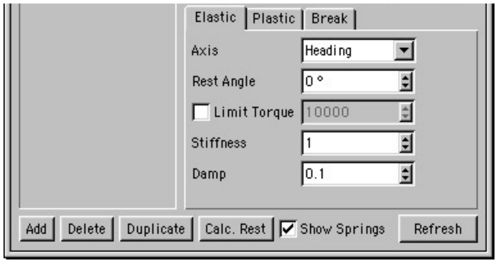
Angular springs — such as those used in old wristwatches — are springs that create torque. Angular springs create rotational motion about the centre of mass. To define the spring to be angular, enable the Angular option.

Enable the Angular option to define the spring as angular such as the type found in an old wristwatch.



Elastic Tab

The options on this tab enable you to define the elastic properties of an angular spring.

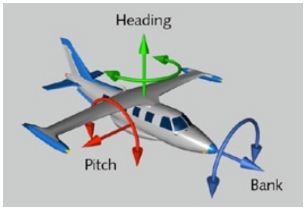


Elastic | Plastic | Break

Axis	Heading
Rest Angle	0 °
☐ Limit Torque	10000
Stiffness	1
Damp	0.1

Axis

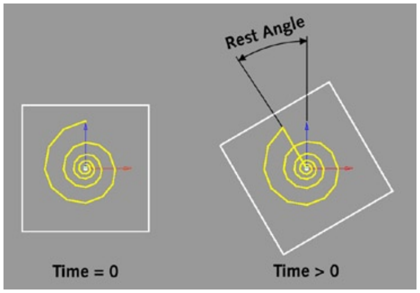
The Heading, Pitch and Bank angles for an aeroplane.



Choose the axis of rotation: Heading, Pitch or Bank. For details on the HPB system, please refer to your CINEMA 4D manual.

Rest Angle

The Rest Angle is the angle at which the spring will exert no force.



The Rest Angle is the angle at which the spring will exert no force. If you set the Rest Angle to a value greater or less than 0, when you start the dynamics animation, the spring and its object will rotate towards and then oscillate about the Rest Angle.

Limit Torque

Sometimes a spring can become so stretched that the massive force it exerts can no longer be processed by the solver object. To prevent this from happening, enable the Limit Torque option. Enter the maximum torque for the spring into the input box.

Stiffness

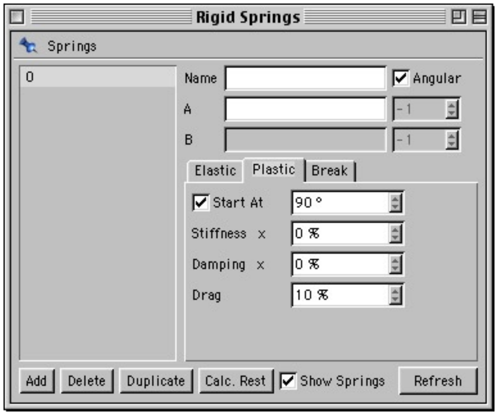
This value defines the stiffness of the spring; the spring constant, that is. A stiff spring will exert more force than a weak spring, all other factors being equal. The greater the Stiffness value, the more force the spring will exert at a given angle.

Damp

A real spring will always be subject to damping due to frictional forces in its material. Without damping, an angular spring would never come to rest. Another good reason for damping your Dynamics springs is that otherwise the springs will tend to gain energy and rotate through a greater angle than they should.

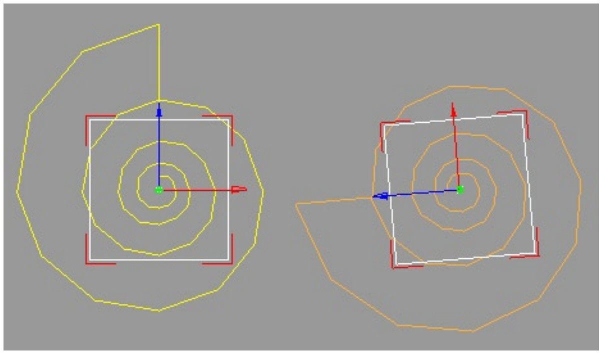
Plastic Tab

The options on the Plastic tab enable you to define at what point an angular spring will remain deformed.



Name:
[✓] Angular
A: -1
B: -1
[✓] Start At: 90 °
Stiffness x: 0 %
Damping x: 0 %
Drag: 10 %
[✓] Show Springs

Angular springs share many of the characteristics of normal springs. As with a normal spring, you can define plastic behavior for the angular spring. The spring will become permanently distorted once it has undergone plastic deformation. Keep in mind that the stiffness and damping of a spring will vary greatly between its elastic state and plastic state. A spring is shaded orange in the viewport when it is in the plastic region.


A spring in the plastic state is shaded orange in the viewport.

Start At

The parameter defines the angle at which plastic deformation will begin. To switch off plastic deformation, uncheck the box.

Stiffness X

This defines the stiffness of the spring during the plastic state, specified as a percentage of Stiffness (Elastic tab). For example, if you set Stiffness X to 20% and Stiffness = 1, the stiffness during the plastic state will be 0.2.

Damping X

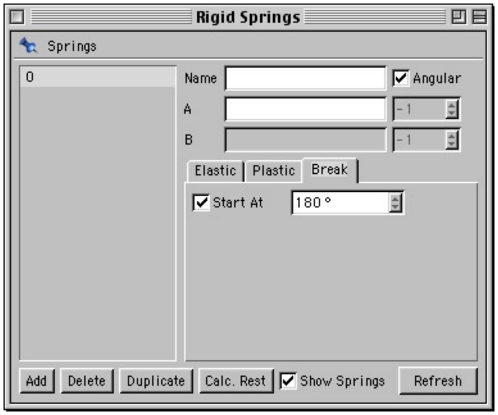
Damping X controls the strength of damping during the plastic state, as a percentage of Damp (Elastic tab). For example, with Damping X set to 50% and Damp set to 0.1, the damping in the plastic region will be 0.05.

Drag

This setting will ensure that the attached objects are damped also while the spring is undergoing plastic deformation. This can be thought of as a drag field that affects the two attached objects only.

Break Tab

The options on the Break tab define at what point an angular spring will lose all of its properties — literally break.



Start At: ✓ 180 °

Start At

Start Above defines the angle at which the spring will break. Once the spring has been broken, it will no longer be able to exert a force on the attached object.

Springs Menu

Add Spring

Adds an undefined spring.

Delete Spring

Deletes all selected springs.

Duplicate Spring

Duplicates the selected spring. You can attach any number of springs between two rigid bodies. However, only one of the springs will be visible in the viewport. Works only when one spring is selected.

Calculate Rest Length

Sets the Rest Length of all selected springs to their current lengths.

Close

Closes the dialog.

Initialization

Initialization is used to set the starting state of the dynamics objects. Two commands are available for this: Initialize Object and Initialize All Objects.

Initialize Object

This command — accessed from main menu (Plugins > Dynamics) sets the starting position of the selected object to its current position.

Suppose you have switched off the Solver object momentarily so that you can move a rigid body. Having moved the rigid body, you then switch on the solver having forgotten to use the Initialize Object command first. The body will revert to its previous position.

Initialize All Objects

The same applies to this function as described above for Initialize Object, with the exception that here the starting positions of *all* rigid bodies and soft bodies will be set to their current positions.

Soft Bodies

Soft bodies are used for simulating objects that change shape over time such as a moving character's clothing or a bouncing rubber ball that squashes as it hits a hard surface.

To know how and when you should use a soft body, it is important to be aware of the main differences between rigid bodies and soft bodies. A rigid body is a solid, polygonal object whose shape does not alter over time. Rigid bodies are able to collide with each other and they can be attached to one another using springs. Unlike soft bodies, rigid bodies can be given a starting angular velocity.

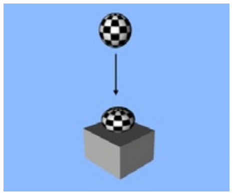
A soft body is a collection of points that are linked together with springs. The shape of a soft body can change over time but, unlike a rigid body, a soft body cannot be given a starting angular velocity. This is because a soft body is built from many masses — a mass for each point of the soft body object. These masses have no initial values for rotation and hence cannot rotate when animated other than through their interactions with other objects.

When using soft bodies, set the solver object's Integration Method to Softbody.

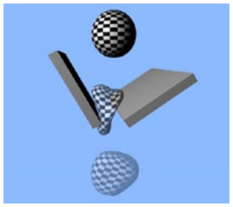
Soft bodies are ideal for simulating of turbulent surfaces such as a flag in the wind or the clothes on a moving character. Because points in the soft body are linked via springs, a force that is exerted on one point will spread out dynamically.

Soft bodies are ideal for simulating cloth such as flags.

Soft bodies can also simulate objects that deform during a collision such as a rubber ball bouncing on a hard surface.


Here, a soft body has been used for the rubber ball, enabling the ball to squash realistically when hitting the block.

Soft bodies have another interesting property: they can squeeze through tight gaps provided they use a low Stiffness setting!


A soft body squeezing through a tight gap thanks to its low Stiffness setting.

Creating a Soft Body

To create a soft body, start with a spline object or polygon object of the desired shape and proceed as follows (note that collision detection requires geometry and hence collision detection is not possible when using splines):

Create a solver object by selecting Plugins > Dynamics > Solver Object from the main menu. Make the polygon or spline object a child of the solver object.

Assign a Soft Body Spring tag to the would-be soft body by selecting File > Dynamics Tags > Soft Body Spring (Object manager menu). The Soft Body dialog will open.

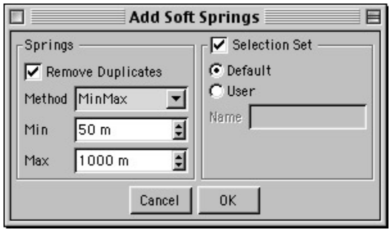
Now the soft body has been created, but as of yet it has no springs. To add the springs, select Plugins > Dynamics > Add Soft Springs from the main menu. In the dialog that opens, set Method to the desired spring type and click OK to add the springs. The soft body is now be ready to be used.

If points are selected when you add the springs, the springs will be added to the selected points only; otherwise, if no points are selected, the springs will be added to all points.

The Add Soft Springs Dialog

This dialog enables you to add springs to the soft body. There are two places where you can access the dialog. Either select Plugins > Dynamics > Add Soft Springs from the main menu or select Springs > Add Soft Springs from the Soft Body dialog. You will be able to access and edit the springs later using the Soft Body dialog.

When you create a soft body, initially it has no springs. Using this dialog, you can add the required springs.
If points are selected when you add the springs, the springs will attach selected points only; otherwise, a layer of springs will be added that covers the entire soft body.


Add Soft Springs

Springs
☑ Remove Duplicates
Method: MinMax
Min: 50 m
Max: 1000 m

☑ Selection Set
● Default
○ User
Name:

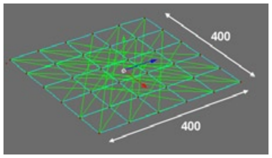
The springs will be attached to points in the soft body using one of several attachment methods. For example, with the Structural method, each point will be connected to its neighboring points, providing a supportive structure to the body.

Remove Duplicates

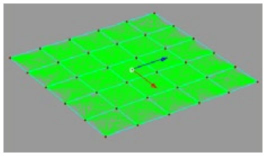
When enabled, this option will delete duplicate springs. A duplicate spring is a spring that attaches the same two points as another spring.

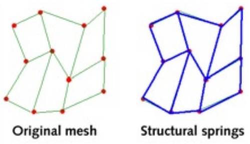
Method

The MinMax diagram shows a plane that is 400 units by 400 units in size. Min has been set to 380, Max has been set to 400. Subsequently each point is connected to points that are from 380 to 400 units away.

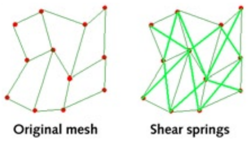


MinMax

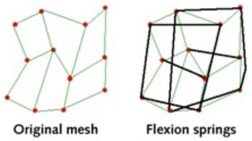

All



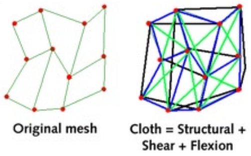
Structural



Shear



Flexion



Cloth

This defines how the springs should be attached to the soft body’s points.

MinMax

Connects each point to all other points within the distance range specified under Min and Max. For example, if you set Min to 40 m and Max to 60 m, each point will be connected to points that are from 40 m to 60 m away.

All

Connects each point to all other points. Use All with caution, it will create an enormous number of springs if the soft body has a large number of points.

Structural

Connects each point to its neighboring points (the points it shares polygon edges with). This attachment method will help the soft body to maintain its shape, hence most soft bodies should have a layer of Structural springs.

Shear

Connects the points in a way that will stabilize four-sided polygons. Without this stabilization, the four-sided polygons could collapse.

Flexion

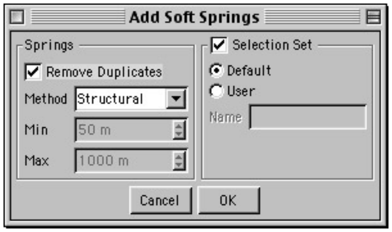
Connects each point to the neighbor of its neighbor. Flexion springs are ideal for giving the soft body a degree of stiffness.

Cloth

Connects the points using a combination of Structural, Shear and Flexion springs. Use Cloth if the soft body should simulate clothes, a flag or another type of cloth.

Selection Set

If Selection Set is enabled, the springs will be added as a selection. After the springs have been added, the selection will then appear in the list area of the Soft Body dialog, under Selections. See the following two diagrams.



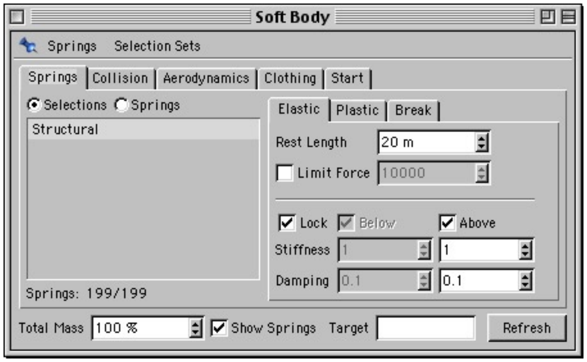
Add Soft Springs

Springs
- [✓] Remove Duplicates
- Method: Structural
- Min: 50 m
- Max: 1000 m

[✓] Selection Set
- (●) Default
- ( ) User
- Name:

Cancel OK

Selection Set enabled. The selection, named Structural, will later appear in the list area of the Soft Body dialog, under Selections.



Soft Body

Springs Selection Sets

Springs | Collision | Aerodynamics | Clothing | Start

(●) Selections ( ) Springs

Structural

Springs: 199/199

Elastic | Plastic | Break

- Rest Length: 20 m
- [ ] Limit Force: 10000
- [✓] Lock [✓] Below [✓] Above
- Stiffness: 1 1
- Damping: 0.1 0.1

Total Mass: 100 % [✓] Show Springs Target: Refresh

The Structural selection in the list area of the Soft Body dialog.

Default

When Default is enabled, the spring selection will be named after the Method setting. For example, if Method is set to Structural, the name will be Structural.

User

Enable this option if you want to enter a name for the selection under Name.

Name

This input box will become enabled when the User option is enabled. Enter your own name for the selection here.

Advice on Adding Springs

Due to the complexity and number of springs in a typical soft body, fail-safe advice is difficult to offer. In general, to simulate a very light material such as a silk cloth fluttering in the wind, use just two layers: Structural and Shear. For other types of cloth, Cloth springs are usually a good choice. Even a rubber ball that distorts when it bounces can be simulated with Cloth springs.

Delete Soft Springs

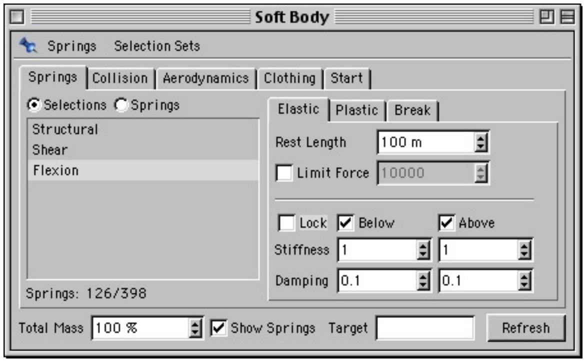
This function deletes all selected springs and all selected spring selections. You can access the function from two different places: either from the Plugins > Dynamics sub-menu (main menu), or from the Springs menu in the Soft Body dialog.

Soft Body Dialog

This dialog is the management centre for soft body springs. Here you have access the springs and spring selections and here you can modify their parameters. In addition, you can also set parameters that relate to the soft body as a whole such as its starting velocity and aerodynamics properties.

Springs Tab

By creating different layers of springs with their own properties you can simulate most types of materials.



[✓ Selections] Springs

Structural
Shear
Flexion

Springs: 126/398

Rest Length: 100 m
[ ] Limit Force: 10000

	[ ] Lock [✓] Below	[✓] Above
Stiffness	1	1
Damping	0.1	0.1

Total Mass: 100 % [✓] Show Springs Target:

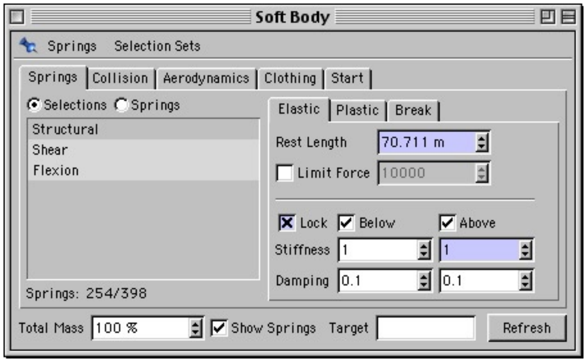
The Springs tab gives you access to the list area where you can select individual springs or selections. It also allows you to access the tabs that define the elastic and plastic deformation properties of the selected springs. You also have access to the Break tab, should you wish for the springs to be able to snap.

The large area in the left half of the Soft Body dialog is the list area. This is where spring selections or individual springs will be shown depending on whether the Selections option or the Springs option respectively is enabled.

You can select more than one spring or spring selection at a time (Shift-click in the list to add to the selection; Ctrl-click to subtract from the selection).

When you edit the parameters in the dialog with several springs selected, the new settings will be applied to all of the selection. When several springs are selected, parameters that have different values for the selected springs will be highlighted in light blue.

When several springs are selected, parameters whose values differ within the selection will be highlighted in light blue.


Soft Body

Springs Selection Sets

Springs | Collision | Aerodynamics | Clothing | Start

[✓ Selections] Springs

Structural
Shear
Flexion

Springs: 254/398

Elastic | Plastic | Break

Rest Length 70.711 m

☐ Limit Force 10000

☒ Lock ☑ Below ☑ Above

Stiffness 1 1

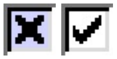
Damping 0.1 0.1

Total Mass 100 % ☑ Show Springs Target Refresh

If you change the setting of a highlighted parameter, the new value will be assigned to all selected springs and the highlighting removed.

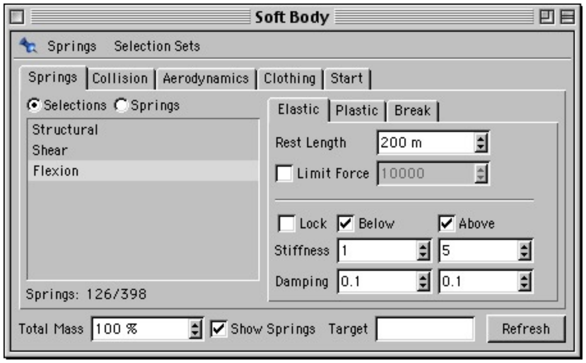
Likewise, if you enter a value into a parameter that is not highlighted, the new value will be assigned to all selected items.

A highlighted cross in an option means that the option has different settings for the selected springs. If you click the option the cross will change into a check and the option will be enabled for all selected springs.



Elastic Tab

On this tab, define the elastic deformation behavior of the selected springs such as strength of damping.



Selections [✓] Springs [ ]

Structural
Shear
Flexion

Springs: 126/398

Rest Length 200 m

Limit Force [ ] 10000

Lock [ ] Below [✓] Above [✓]

Stiffness 1 5

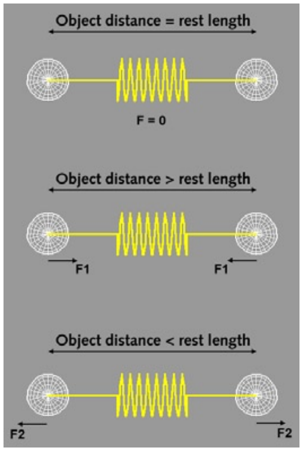
Damping 0.1 0.1

Total Mass 100 % Show Springs [✓] Target

Rest Length

The Rest Length defines the normal length of the spring; that is, the length at which the spring will exert no force. In the diagram below, the top spring is at its rest length and hence it is exerting no force on the objects.

The Rest Length is decisive in determining whether the spring will push, pull or exert no force on its attached objects.


Object distance = rest length
F = 0
Object distance > rest length
F1
F1
Object distance < rest length
F2
F2

If you attach two objects using a spring whose Rest Length value is less than the distance between the two objects, the spring will be stretched because of this and will exert a force on the two bodies that attempts to pull them towards the rest length. Conversely, if the Rest Length value is greater than the distance between the two attached objects, the spring will be compressed because of this and will exert a force on the two objects that attempts to push them away from one another and towards the rest length.

Limit Force

In some cases, the force exerted by a spring can become too great for the solver object to process. Hence under Limit Force you can specify the maximum force that the spring will be allowed to exert.

Lock

When enabled, this option will lock the Below values to be the same as the Above values.

Below

This option and the Stiffness and Damping parameters below it define the spring's behavior when the spring is below its rest length (i.e. compressed). By default, these settings are ghosted by the Lock option, which locks the Below parameters to the same settings as the Above parameters. To be able to define separate values for compression, disable the Lock option.

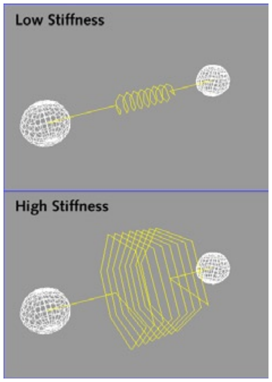
Above

This value refers to the spring when it is above its rest length (stretched, that is). If Above is enabled, the Stiffness and Damping values will be applied while the spring is stretched. With the option disabled, the spring will be limp when stretched and it will thus exert no force.

Stiffness

These two input boxes define the stiffness of the spring for the Below and Above options. The higher the value, the greater the force that will be exerted by the spring when it is stretched or compressed. Also, like a real spring, a stiff spring will be much harder to compress or stretch than a weak spring.

A spring's Stiffness affects its diameter in the viewport.



The Stiffness value of the spring is indicated in the viewport: the stiffer the spring is, the greater its diameter will be.

The Stiffness also affects the spring's rate of oscillation, with a stiff spring tending to oscillate faster than a weak spring because of the greater force that it exerts on the objects it is attached to.

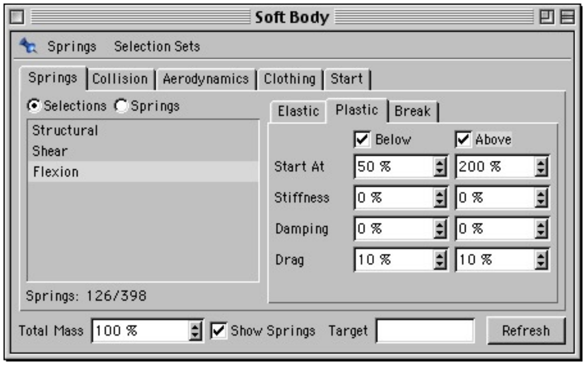
Damping

Like Stiffness, there are two input boxes. The left-hand input box defines the damping for the Below option; the right-hand input box defines damping for the Above option.

All real springs will experience damping while oscillating due to resistance within their material. Without damping, a spring would oscillate endlessly. For realistic damping, enter a value from 0.1 to 0.5.

Plastic Tab

Using these parameters, you can define how the selected springs will behave when undergoing plastic (that is, permanent) deformation. For example, you can define how much the spring must be stretched or compressed before it will undergo plastic deformation.


Soft Body
Springs Selection Sets
Springs | Collision | Aerodynamics | Clothing | Start
Elastic | Plastic | Break
Refresh

[✓ Selections] Springs

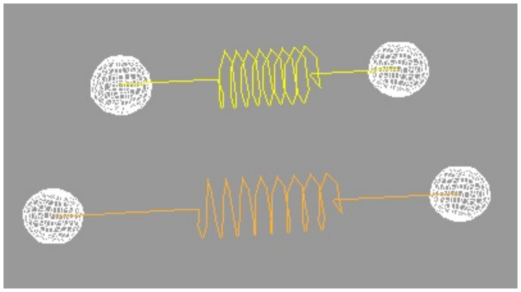
Structural
Shear
Flexion

Springs: 126/398

	Below ✓	Above ✓
Start At	50 %	200 %
Stiffness	0 %	0 %
Damping	0 %	0 %
Drag	10 %	10 %

Total Mass 100 % ✓ Show Springs Target

When you stretch a spring past its elastic limit, the spring will become permanently distorted — termed plastic deformation. On this tab, you can set the parameters that will simulate plastic deformation for your virtual spring.



Above: A spring in the elastic state. Below: The same spring, this time in the plastic state. Springs in the plastic state are shaded orange in the viewport.

Using Below and Above, you can define the plastic properties of the spring when compressed and when stretched. Keep in mind that a spring's stiffness and damping will change greatly between elastic deformation and plastic deformation.

Below

Enable this option if you want to define the plastic properties of the spring (Start At, Stiffness, Damping, Drag) when it is below its rest length (compressed, that is).

Above

When Above is enabled, you can define the plastic properties of the spring (Start At, Stiffness, Damping, Drag) when it is above its rest length (stretched, that is).

Start At

This defines the length at which plastic deformation will begin, specified as a percentage of the Rest Length (Elastic tab). For example, if you enter a value of 200% and Rest Length = 10 m, plastic deformation will start when the spring is 20 m long.

Stiffness

Use Stiffness to set the stiffness of the spring for plastic deformation. The value must be defined as a percentage of Stiffness (Elastic tab). For example, if you enter a Stiffness value of 10% (Plastic tab) and Stiffness = 5 (Elastic tab), the stiffness of the spring during its elastic state will be 0.5.

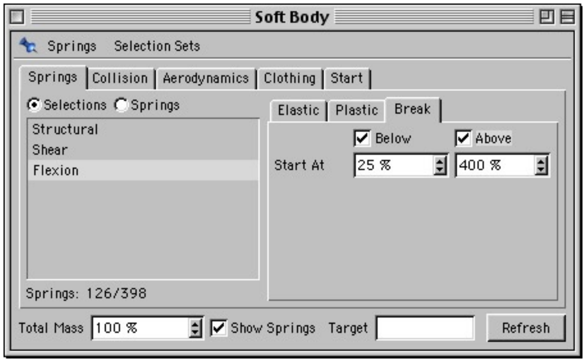
Damping

Damping controls the strength of damping for the plastic state, defined as a percentage of Damping (Elastic tab). For example, with Damping here set to 50% and Damping on the Elastic tab set to 0.1, the damping during the plastic state will be 0.05.

Drag

This setting will ensure that the attached objects are damped while the spring is undergoing plastic deformation. This can be thought of as a drag field that affects the two attached objects only.

Break Tab



(●) Selections ( ) Springs

Structural
Shear
Flexion

Springs: 126/398

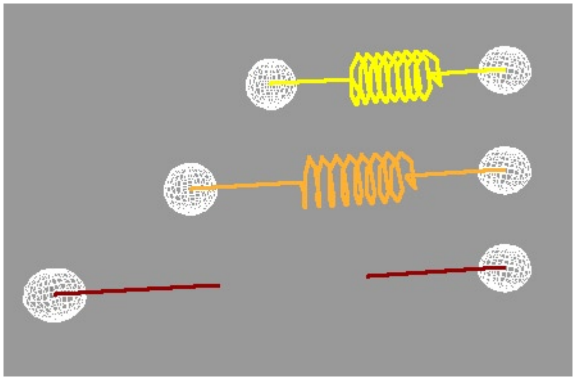
[✓] Below [✓] Above

Start At 25 % 400 %

Total Mass 100 % [✓] Show Springs Target

The break tab is used to specify if - and if so, at what length - the selected springs will break.

Like a real spring, Dynamics springs can be made to snap if you stretch them too far. Before a real spring snaps, it will first undergo elastic deformation followed by plastic deformation.



The sequence of events leading to snapping: elastic deformation (top), plastic deformation (middle), snapping (bottom). A broken spring is shaded red in the viewport.

Once the spring has been broken, it will no longer be able to exert force on the attached objects.

Below

Enable this option to allow the spring to break when compressed. Define the breaking point using Start At.

Above

For snapping to be possible, the spring must have its plastic state defined — that is, Below and/or Above must be enabled on the Plastic tab. However, you can, if you wish, still have the spring snap without it first having to undergo plastic deformation: set the Start At parameters on the Plastic tab and the Break tab to the same value.

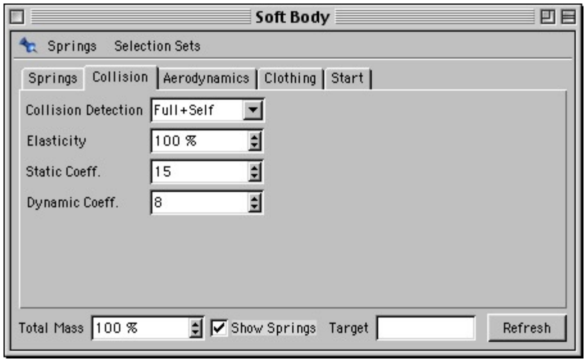
Enable this option if the spring should break when stretched. Define the point at which the spring should break under Start At.

Start At

These two input boxes set the breaking point for the Below option (left-hand input box) and the Above option (right-hand input box). Into the input boxes, enter the breaking point as a percentage of the Rest Length (Elastic tab). For example, if Start At is set to 300% and Rest Length = 200 m, the spring will snap when it is 600 m long.

Collision Tab

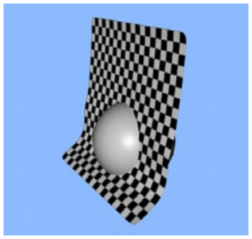
Collisions of soft bodies is slower than rigid body collisions; using as few springs as possible will enable you to reduce the pressure on your solver, helping to speed up the overall processing of the dynamics.

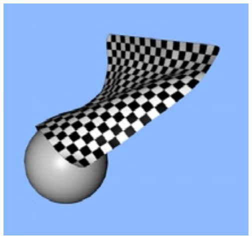


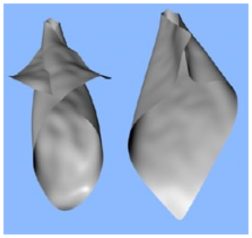
Collision Detection Full+Self
Elasticity 100 %
Static Coeff. 15
Dynamic Coeff. 8
Total Mass 100 %
[✓] Show Springs
Target

Collision detection is not just for rigid bodies. With this tab, you can switch on collision detection for the soft body. Unfortunately there are no tricks for soft body collisions that will help you to save processing time. Here, a proxy collision object is of no use. Collision detection with soft bodies is always a processor-intensive affair.

Collision Detection


None


Full


Full (left), Full+Self (right)

This defines the collision mode: None, Full or Full+Self.

None

Switches off collision detection.

Full

Checks each point for collision with other bodies but does not check for self collision. This is suitable for draping cloth over an object.

Full+Self

Checks each point for collision with other bodies and also checks for self collision. Use this setting if the soft body would otherwise intersect itself. One example is a flag in a strong wind.

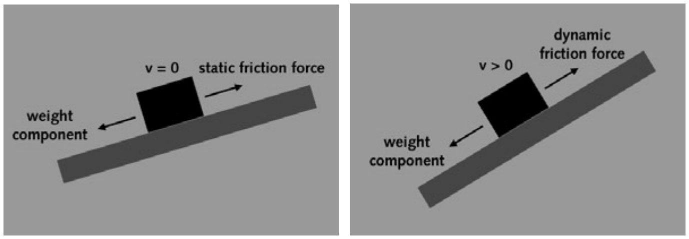
Elasticity

This value defines the percentage of energy that the soft body will retain following a collision. An Elasticity setting of 0% would cause the soft body to halt suddenly during the collision while a value of 100% would see the soft body rebound.

Static Coeff. Dynamic Coeff.

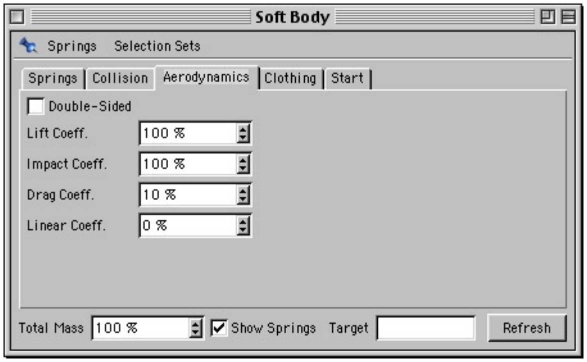
When two bodies are in contact, friction will exist between the bodies. This will be static friction if the bodies are at rest, or dynamic friction is one body is sliding over the other. Static friction should always greater than dynamic friction: more energy is required to get a body moving than is required to keep it moving.

Left: The block's weight component down the incline is not great enough to overcome static friction. Hence the block is not sliding. Right: The incline of the ramp has been increased and the block is now sliding down the ramp. Static friction having been overcome, the block is now being resisted instead by the lesser force of dynamic friction.



Aerodynamics Tab

Material soft bodies generally consist of a deformed plane; using the Double-Sided option will give a more realistic movement with the wind.



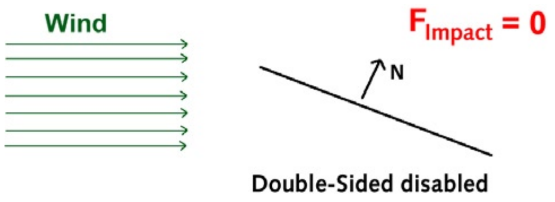
Double-Sided: ☐
Lift Coeff. 100 %
Impact Coeff. 100 %
Drag Coeff. 10 %
Linear Coeff. 0 %
Total Mass 100 %
Show Springs: ✓
Target

The parameters on the soft body's Aerodynamics tab relate to those defined in the wind force field's dialog. For example, if Frontal Coeff. is set to 120% in the Wind dialog and 50% here in the Soft Body Spring tag, the effective Frontal Coeff. will be 60%.

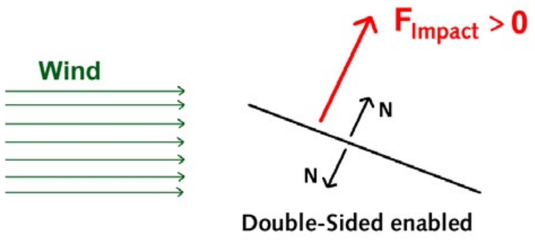
Double-Sided

When this option is disabled — the default setting — the wind will affect only those polygons whose surface normals are facing the wind. If you enable the option, the wind will exert its force on all polygons regardless of the direction in which their surface normals are pointing. Only enable the Double-Sided option if your object has no thickness and Lift Coeff. is set to 0.

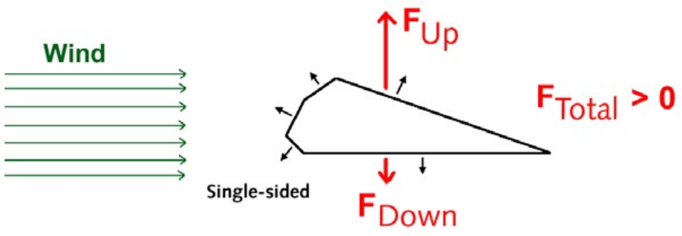
Double-Sided disabled. Since the normal is facing away from the wind, the wind is unable to exert a force on the surface.



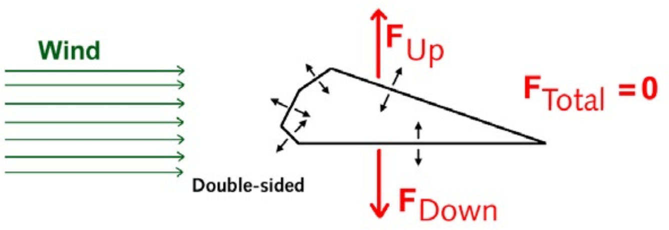
Double-Sided enabled. This guarantees that a normal will face the wind and hence the wind is now able to exert a force on the surface.



Double-Sided disabled. The wing is experiencing a lifting force.



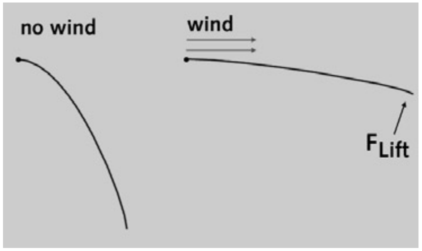
Double-Sided enabled, causing equal and opposite forces for each surface and hence no resultant force. For closed polygons, Double-Sided should be disabled.



Lift Coeff.

This setting defines the strength of lift. When an airstream passes over a surface, the air pressure will drop. The faster this airstream, the lower the pressure. When designing a wing, the wing must be shaped so that the airstream will pass over one wing surface more quickly than over the other wing surface. This will create a pressure gradient, causing the wing to experience a lifting force.

If you were to hold out a piece of paper and blow along its top edge, the airstream would create lift — as the airstream passes over the paper, it is lifted up so that it is flat in the airstream with equal air pressure above and below.



A practical example of lift. Blow across a hanging piece of paper and the airstream will create a lift force that will move the paper into line with the airstream.

Occasionally, paradoxical situations may arise such as motion that heads into the wind. In such a case you should reduce the Lift Coeff. in one of two places. You can reduce the parameter either in the Wind field or the Soft Body tag. The latter is usually preferable since it enables you to adjust the lift for a uncooperative object without affecting the flight of the other objects.

Impact Coeff.

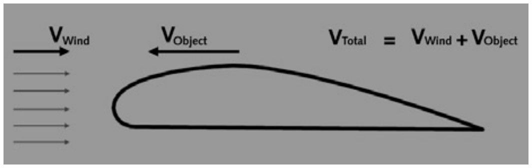
The Impact Coeff. value determines the strength of the air force that will be exerted on body surfaces that face the wind. The strength of the impact force is proportional to the surface area facing the wind and the relative velocity of the body compared to the wind.

Drag Coeff.

When air streams over a body, small eddies will beat against the body's surfaces, causing deceleration. The Drag Coeff. parameter defines the strength of this effect. This decelerating effect is usually minor but occasionally it can have a telling influence on the object's motion.

Linear Coeff.

This setting relates to linear velocity, which plays a part in an object's motion in the wind force field. However, it is not just the wind's velocity that needs to be taken into account, but the object's velocity also.



The velocity will affect an object's behavior in wind. The effective velocity that will be considered is the sum of the wind's velocity and the object's velocity.

Example 1

An aeroplane is taking off at 100 km/h and heading into a wind of 50 km/h. The relative wind velocity that is affecting the wing's surface is 150 km/h.

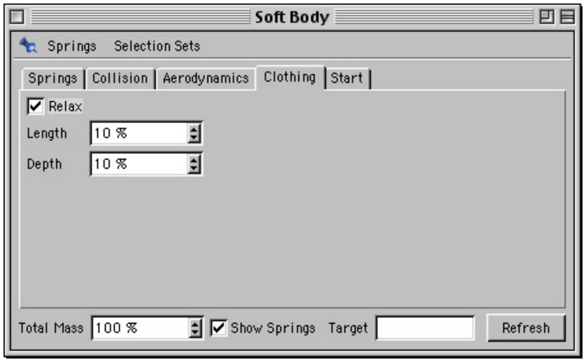
Example 2

A plane is taking of at 100 km/h with a following wind of 50 km/h. Hence the relative wind velocity is just 50 km/h. This highlights the reason why aeroplanes will take off from various runways according to the direction of the wind.

Linear Coeff. defines the strength of this effect for linear motion. For a realistic effect, leave Linear Coeff. in the Wind dialog set to 100% but set Linear Coeff. here in the Soft Body dialog to a value from 1% to 10%.

Clothing Tab

Using this tab, you can make the springs relax for a much better simulation of cloth.



Soft Body

Springs | Selection Sets

Springs | Collision | Aerodynamics | Clothing | Start

☑ Relax

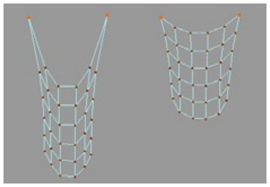
Length	10 %
Depth	10 %

Total Mass 100 % ☑ Show Springs Target Refresh

Relax

Enable this option if the soft body should be cloth-like. This works by relaxing the springs, as shown in the diagram below.

In the diagram, two cloths are hanging from their top corner points in a gravity force field. The Relax option has been disabled for the cloth on the left. The whole mass of the soft body is hanging from four springs that are being stretched accordingly. As a result, the left cloth is behaving more like soft rubber than cloth. With the cloth on the right, the Relax option has been enabled, allowing a more natural simulation of cloth.



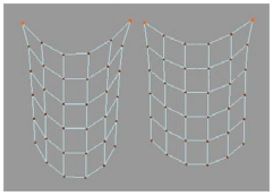
Length

Defines the length at which the springs will begin to relax. For example, if Length is set to 10%, springs that are 10% longer than their Rest Length will be relaxed.

Depth

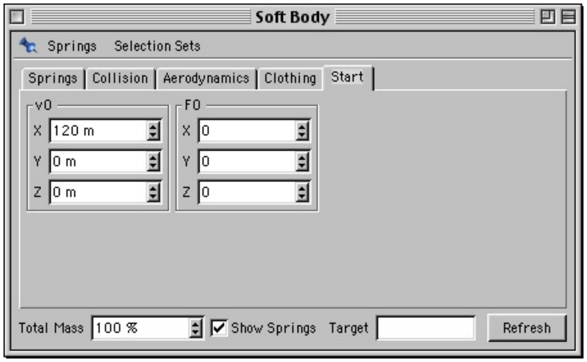
The higher this value, the more even the relaxation of the springs inside the soft body. Forces exerted on the most strained springs will be spread among the surrounding springs. A higher value means a wider distribution of the exerted forces.

In the diagram, two soft bodies are hanging from their top corner points in a gravity field. The soft body on the right is using a high Depth value and so the force is being shared fairly evenly by its springs. Contrast this to the uneven stretching in the left soft body, which is using a low Depth value.



Start Tab

This tab enables you to define a starting velocity for the soft body.



v0
X 120 m
Y 0 m
Z 0 m

F0
X 0
Y 0
Z 0

Total Mass 100 %
[✓] Show Springs
Target

v0

Defines the starting velocity (X, Y, Z) of the soft body.

F0

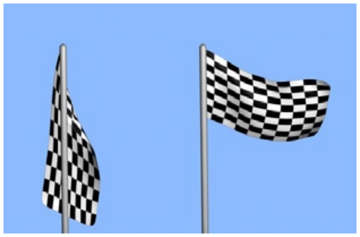
Defines a starting force (X, Y, Z) that will be exerted during the first frame of the animation only.

Total Mass

Initially, each point in a soft body will have a mass of 1. Using this parameter, you can change the total mass of the points.

Suppose you want to create a flag in the wind, but rather than flapping as intended, the flag is hanging limply. Although you could correct this by adjusting the parameters in the Wind dialog, it is easier to reduce the Total Mass of the flag’s points.

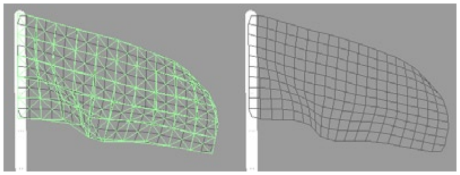
Two flags in the same wind force field. Left: high Total Mass value; right: low Total Mass value.



A higher mass is synonymous with a higher inertia. A soft body with a large inertia will be stiffer and more sluggish. For example, a silk cloth should have a lower Total Mass than a sail (unless you prefer to adjust the motion using the aerodynamics parameters).

Show Springs

Show Springs enabled (left flag) and disabled (right flag).



Controls whether springs are displayed in the viewport.

Springs Menu

Add Soft Springs

Opens the Add Soft Springs dialog, described earlier in this chapter.

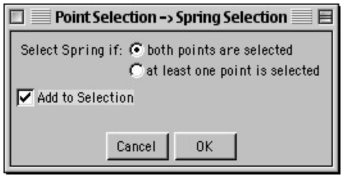
Delete Soft Springs

Deletes all selected springs and all selected spring selections. You can access the function from two different places: from here or from the Plugins > Dynamics menu of the main menu.

Point Selection -> Spring Selection

Converts an existing point selection into a spring selection. After selecting the command, the following dialog will open:

Using this dialog, you can select springs from an existing point selection.



Point Selection -> Spring Selection

Select Spring if: [✓ both points are selected] at least one point is selected

✓ Add to Selection

The first option, Select Spring If Both Points Are Selected, will select springs that have both attachment points selected.

Select Spring If At Least One Point Is Selected will select springs that have one or both points selected.

Enable Add To Selection if you want to add the springs to the current selection.

Select All

Selects all the springs in the list area.

Deselect All

Deselects all springs.

Invert Selection

Inverts the selection. Selected springs will become deselected and deselected springs will become selected.

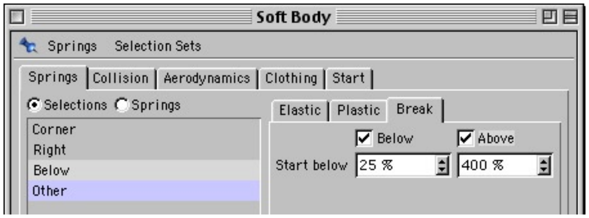
Close

Closes the Soft Body dialog.

Selection Sets Menu

Save Spring Selection

Saves an existing spring selection under a name of your choosing. This is the name that will be shown in the list area.



[✓ Selections] Springs

Corner
Right
Below
Other

[✓ Below] [✓ Above]

Start below 25 % 400 %

Here, the user has clicked the spring selection called Below. Note how Other is highlighted in blue. This indicates that one or more springs in the Below selection are also present in the Above selection.

Rename

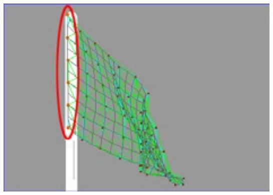
Renames a spring selection.

Delete

Deletes a spring selection.

Set Soft Mass

You can reach this important function plugin from the Plugins > Dynamics menu of the main menu. Set Soft Mass allows you to define the mass of individual soft body points. In particular, this is useful for fixing some of the points in place — set the mass of the points you want to fix to 0. As previously mentioned in this manual, points and bodies that have a mass of 0 will not be animated by the dynamics engine.


A soft body flag in a wind force field. The six left-most points of the flag have been given a mass of 0. As a result, these six points are being ignored by the wind whereas the rest of the soft body points are flapping.

Set Soft Mass is also useful for varying the mass for specific points. This can help you to tweak the animation behavior for important parts of the soft body. Note that you can animate soft body points of zero mass using keyframes; the keyframed points will pull the other points along.

Initialize Soft Rest Length

Sets the Rest Length of each spring in the soft body to its current length. The command is accessed from the Plugins > Dynamics menu of the main menu.

Constraints

If you need to restrict the motion of a rigid body in some way, for example if the rigid body should always remain on the Y = 0 plane, then you need to use constraints.

Constraints are used to restrict the motion of objects. Using constraints you can fix the position of a rigid body to a particular axis or combination of axes. For example, you can constrain a rigid body to move along the Z axis only. You can also fix the rotation of the rigid body to a particular angle and you can link rigid bodies together. Many real objects are constrained in one way or another. A pendulum rotates about its pivot point only. A link in a chain has its movement restricted by the other links. The sails of a windmill turn in the wind while the building itself remains stationary. All of this motion and more can be achieved with the help of constraints.

You can use multiple Constraint tags per rigid body. For example, to define a Motor constraint and a Velocity constraint for the same rigid body, use two Constraint tags — one for the Motor constraint and the other for the Velocity constraint.

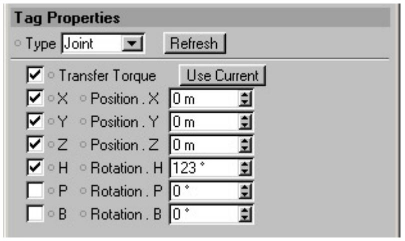
The Constraint Tag

Using this tag you can define how the rigid body should be constrained. Note that you should place the rigid body in a position within the constraints, otherwise the rigid body may take several animation frames to reach the required position. The settings displayed in the Attribute manager for the Constraint tag will vary depending on which type of constraint you've specified using the Type parameter. You can set Type to Joint, Velocity or Motor.

Joint

Point to Point

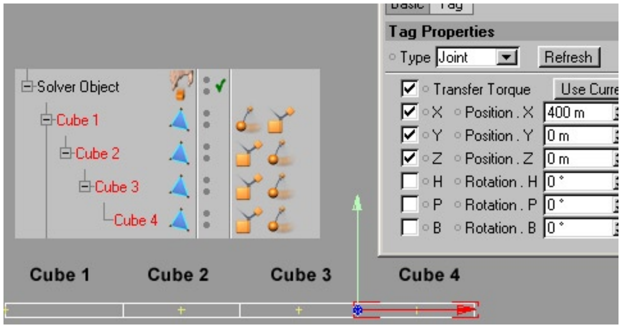
If Type is set to Joint, the rigid body will be fixed to the position defined by X, Y and Z.


Tag Properties
Type: Joint
Refresh

✓	Transfer Torque	Use Current	
✓	X	Position . X	0 m
✓	Y	Position . Y	0 m
✓	Z	Position . Z	0 m
✓	H	Rotation . H	123 °
☐	P	Rotation . P	0 °
☐	B	Rotation . B	0 °

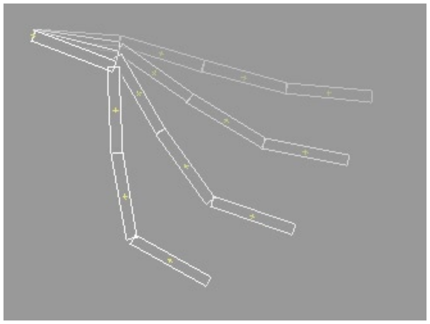
This type of constraint will fix the rigid body to the position defined under X, Y and Z. Note that this position must be stated using the coordinate system of the parent object. For example, if X, Y and Z are set to 0,0,0, the rigid body will be placed at position 0,0,0 of the parent's coordinate system.

Objects in a hierarchy can be linked to each other using Constraint tags.



Shown in the diagram above are four cubes. Cube 4 is a child of Cube 3, which in turn is a child of Cube 2, which in turn is a child of Cube 1. The origin of each cube has been placed at the cube's left edge — don't let the yellow cross confuse you; it represents the mass centre. Cube 2, Cube 3 and Cube 4 have each been assigned a Constraint tag with Type set to Point and X set to 400. These tags will keep each cube 400 units apart along the parent's X-axis.

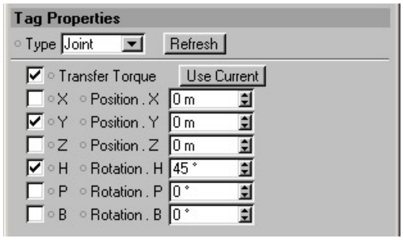
Four cubes in a gravity field. The cubes are being kept a fixed distance apart by their Constraint tags.



In the diagram above, the four cubes have been placed in a gravity field. Due to the Constraint tags, the cubes remain linked while the chain is swinging down under the force of gravity.

Point to Plane

Y set to 0. Therefore the object will remain on the Y = 0 plane.



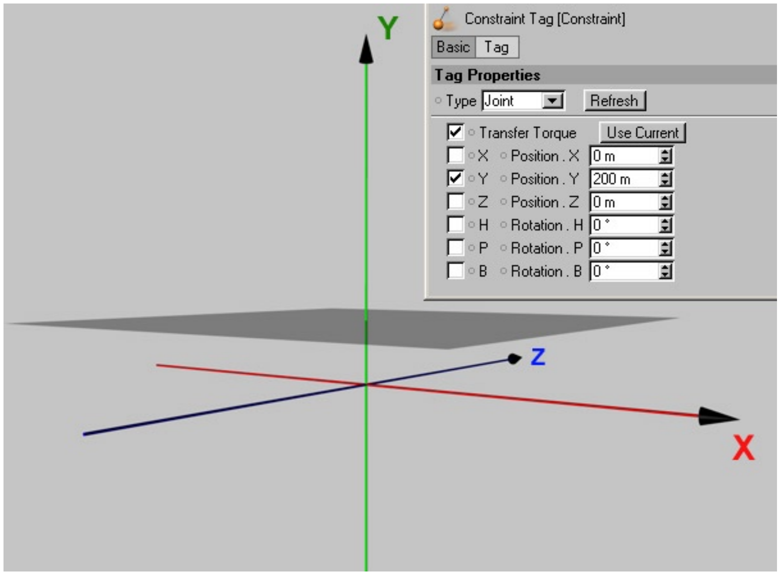
Tag Properties

Type: Joint — Refresh

✓	Transfer Torque		Use Current
☐	X	Position . X	0 m
✓	Y	Position . Y	0 m
☐	Z	Position . Z	0 m
✓	H	Rotation . H	45 °
☐	P	Rotation . P	0 °
☐	B	Rotation . B	0 °

This will constrain the rigid body to a plane. For example, to allow the rigid body to move along the Y = 0 plane only, set Y to 0.

Y has been set to 200. As a result, the rigid body will be allowed to move along the Y=200 plane only, which is indicated by the dark square.



Constraint Tag [Constraint]

Basic | Tag

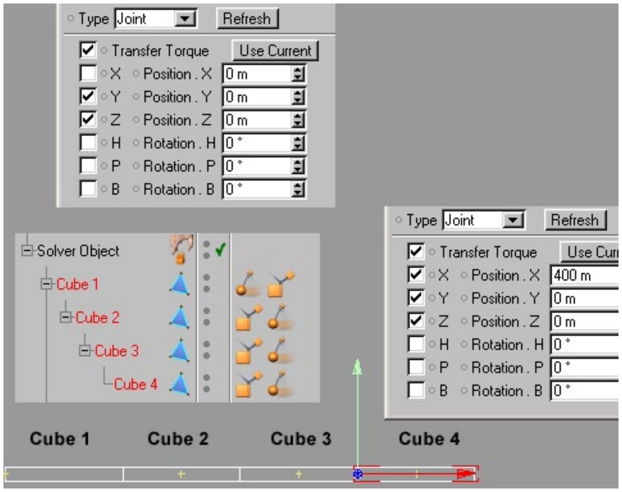
Tag Properties

Type: Joint — Refresh

✓	Transfer Torque		Use Current
☐	X	Position . X	0 m
✓	Y	Position . Y	200 m
☐	Z	Position . Z	0 m
☐	H	Rotation . H	0 °
☐	P	Rotation . P	0 °
☐	B	Rotation . B	0 °

With Y set to 200, movement will be allowed along the Y= 200 plane only.

In the Constraint dialog for Cube 1, X has been disabled. This will allow Cube 1 to move freely along the X-axis.

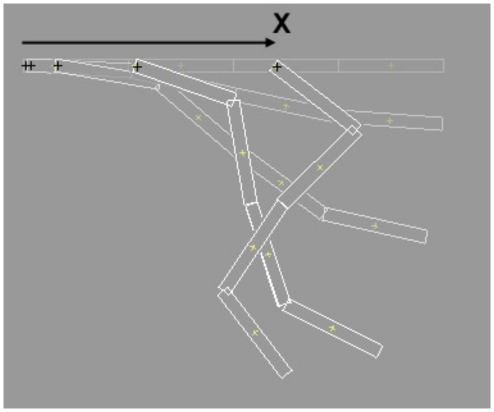


	Type	Joint	Refresh
✓	Transfer Torque		Use Current
☐	X	Position . X	0 m
✓	Y	Position . Y	0 m
✓	Z	Position . Z	0 m
☐	H	Rotation . H	0 °
☐	P	Rotation . P	0 °
☐	B	Rotation . B	0 °

	Type	Joint	Refresh
✓	Transfer Torque		Use Cur
✓	X	Position . X	400 m
✓	Y	Position . Y	0 m
✓	Z	Position . Z	0 m
☐	H	Rotation . H	0 °
☐	P	Rotation . P	0 °
☐	B	Rotation . B	0 °

For the top cube in the above diagram, X has been disabled while Y and Z have both been set to 0. Therefore the top cube is able to move freely along the X-axis only.

The chain of cubes has been placed in a gravity field. The top cube is able to move freely along the X-axis.



Use Current

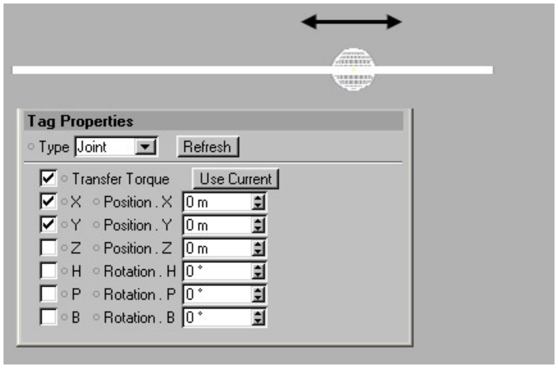
If you click this button, the X,Y,Z and H,P,B input boxes will be set to the rigid body’s current position and direction.

Angle Constraints H,P and B

When enabled, these options will align the rigid body to the angle specified in the adjacent input boxes. The angle must be specified using the parent's coordinate system. You can recreate many of the joints found in nature and robotics by combining position constraints with angle constraints.

Prismatic

This sphere has a prismatic joint, meaning that it can be moved along one axis only — in this case, the Z-axis.


Tag Properties

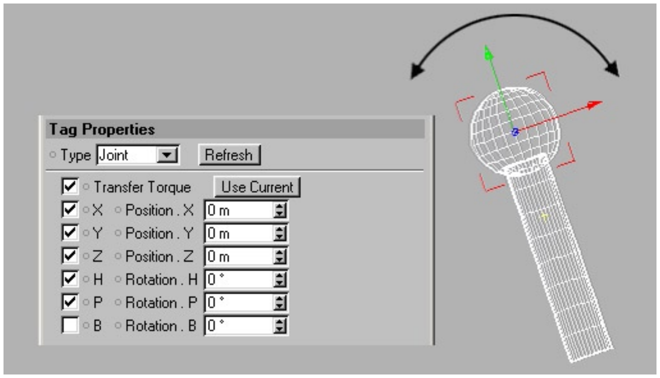
Type: Joint | Refresh

✓	Transfer Torque	Use Current	
✓	X	Position . X	0 m
✓	Y	Position . Y	0 m
☐	Z	Position . Z	0 m
☐	H	Rotation . H	0 °
☐	P	Rotation . P	0 °
☐	B	Rotation . B	0 °

A prismatic joint is a joint that can be moved along a single axis only. Commonly used for robotic joints.

Ball and Socket

The ball and socket joint allows rotation in many directions. The position should be fixed by entering values for X, Y and Z.


Tag Properties

Type: Joint | Refresh

✓	Transfer Torque	Use Current	
✓	X	Position . X	0 m
✓	Y	Position . Y	0 m
✓	Z	Position . Z	0 m
✓	H	Rotation . H	0 °
✓	P	Rotation . P	0 °
☐	B	Rotation . B	0 °

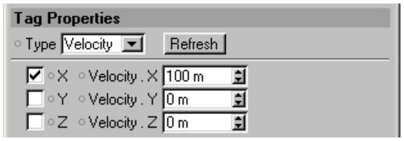
This flexible ball and socket joint allows movement in many directions. Examples of ball and socket joints include the shoulder and hip joints of the human body.

Transfer Torque

This should always be enabled to allow the transfer of torque between linked objects.

Velocity

You can constrain the velocity of the rigid body by setting Type to Velocity.


Tag Properties

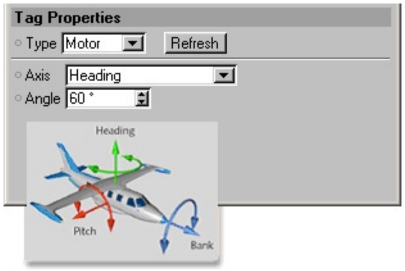
Type Velocity Refresh

✓	X	Velocity . X	100 m
	Y	Velocity . Y	0 m
	Z	Velocity . Z	0 m

This type is used to constrain the rigid body's velocity. For example, if you set Velocity.Z to 100, the rigid body will have a constant velocity of 100 units in the Z direction regardless of any forces that the solver may exert.

Motor

With Type set to Motor, you can constrain the rigid body to a constant angular velocity.


Tag Properties

Type Motor Refresh

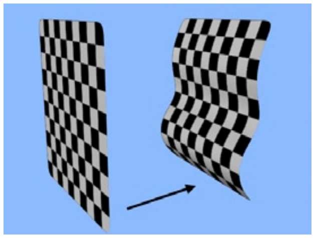
Axis Heading

Angle 60 °

If you set Type to Motor, the rigid body will rotate at a constant angular velocity as defined under Angle. Set the rotation axis under Axis.

Soft Constraints

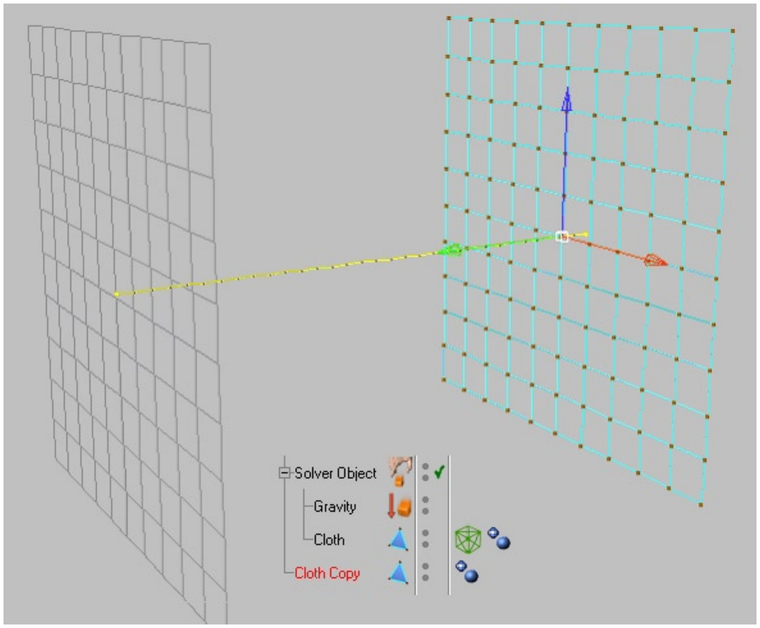
Although Constraint tags work for rigid bodies only, the following workaround will enable you to constrain the motion of soft bodies. Suppose you have placed a cloth in a gravity field. The cloth should adopt the shape indicated below (right cloth).


Left: the starting shape of the cloth. Right: the shape the cloth should adopt.

To make the cloth adopt the required shape:

Create a non-dynamic copy of the soft body, in other words a copy without dynamics tags.

Animate the copy using keyframes.

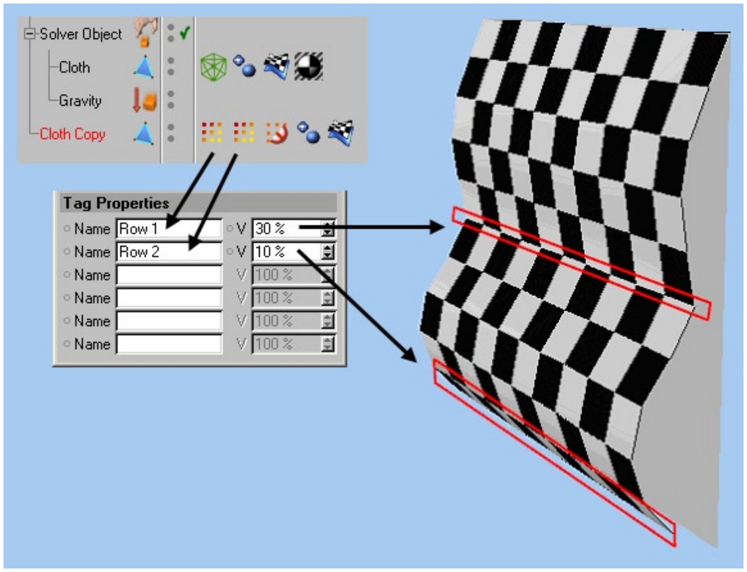


Here, the position of the copy has been animated.

In the Soft Body dialog of the soft body, under Target, type in the name of the copy. All soft body points of zero mass will now follow the copy.

The next stage is to assign a vertex map and Restriction tag to the copy. So select the relevant points and weight them appropriately using the Set Vertex Weight command (select Selection > Set Vertex Weight from the main menu). Next, give a name to the vertex map.

If you now create a Restriction tag by selecting File > CINEMA 4D Tags > Restriction from the Object manager, you will be able to adjust the strength of up to six vertex maps. The strength controls how closely the soft body points will follow the copy.



Name	Row 1	V	30 %
Name	Row 2	V	10 %
Name		V	100 %
Name		V	100 %
Name		V	100 %
Name		V	100 %

The chequered cloth is the soft body, the grey rectangle just to its right is the copy. Two vertex maps have been created: Row 1 (Strength = 30%) and Row 2 (Strength = 10%). The two point rows are following the copy with varying strength.

Keyframe Animation

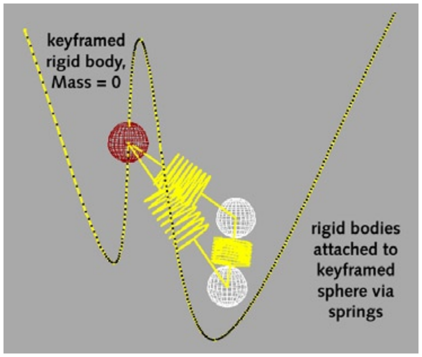
With dynamics there are several ways to animate objects in CINEMA 4D. This means that conflict situations can arise. Solutions are a few clicks away!

Throughout all of dynamics the control of the motion is taken out of your hands once you click Play. In many animations you need to have exact control over positions and movements of objects. This precise control and timing can only be achieved with some keyframing. This poses the questions of how keyframing can be used alongside or even within the dynamics itself and what conflicts this may give rise to.

Suppose you have animated a sphere with keyframes so that the sphere moves upwards. You have then added a Rigid Body Dynamic Tag which, with the help of a gravity field, wants to pull the sphere downwards. Both are not possible, so who wins, keyframes or dynamics?

There is a solution. The trick is to set the Mass values of the rigid body or soft body points to zero. The dynamics engine will not exert forces on any objects of mass zero. A second property of these zero-mass objects is that you can animate them with keyframes. Thirdly, you can attach springs to zero-mass objects; this makes it possible to link keyframes and dynamics.

Dynamics will not exert forces on any objects that have zero mass, leaving you free to animate them with keyframes.

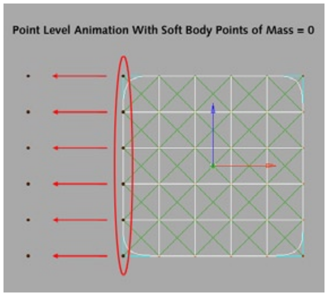

keyframed rigid body, Mass = 0
rigid bodies attached to keyframed sphere via springs

In the diagram above, the dark sphere is a zero-mass rigid body that is moving along the animation path (keyframe animation). The other two spheres are linked to the first sphere via springs. During the animation, the keyframed sphere will drag the rigid bodies with it.

Rigid bodies that have keyframes will still be able to collide with other rigid bodies and soft bodies. Collision detection must be enabled for all the objects involved.

Using the same technique — setting the Mass values to zero — you can animate the points of the soft body with Point-Level Animation.

Soft bodies with zero masses may be animated with point-level animation.



The rest of the soft body will follow the animated points. This method enables you to move soft bodies without having to use force fields.

Parameter Animation for Gravity, Wind and Drag

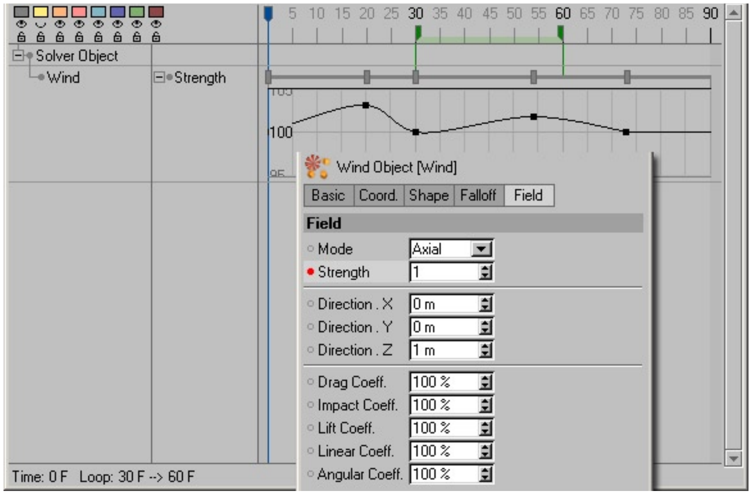
The following areas of dynamics can be animated:

• Gravity • Wind • Friction • Constraint tag • Solver object
• Rigid Body Dynamic tag

For realistic wind, vary the Strength and Direction parameters.

Proceed with caution when animating Solver objects or Rigid Body Dynamic tags — unexpected effects are possible! Although parameters such as Integration Method can be animated, there isn't much point in animating these parameters anyhow.

Using parameter tracks you can animate dynamics force fields.



Field

Mode	Axial
Strength	1
Direction . X	0 m
Direction . Y	0 m
Direction . Z	1 m
Drag Coeff.	100 %
Impact Coeff.	100 %
Lift Coeff.	100 %
Linear Coeff.	100 %
Angular Coeff.	100 %

Baking a Dynamics Animation

Because of the differences in the way decimal numbers are calculated on different platforms, moving a dynamics animation across platforms may require the values to be tweaked on the new platform. The only way to avoid this problem is to 'bake' individual solver objects or the entire scene so that the animation is turned into a set of keyframes rather than movement that has to be calculated.

Dynamics allows you to bake all dynamics motion in the Timeline. This has several advantages:

After baking, you can edit the animation using the Timeline.

The animation will run much faster in the viewport once baked.

Baking will ensure that the animation runs exactly the same on another computer (without baking, the animation may run differently on another computer due to differing processor accuracy).

After baking you can render over a network using the NET Render module.

After baking you can export the animated objects to other programs via a file format such as FBX.

Baking will take approximately as long as the time it would take the dynamics animation to play in the viewport so, in some cases, baking may take a considerable time. You can abort the baking process at any time by pressing the Esc key.

Once baking has completed, the Solver object will be switched off automatically and you will be able to play back the animation. The moment you switch on the solver, the dynamics engine will take over.

Any existing tracks in the Timeline will be overwritten during baking, assuming the same timeline layer is being used. Rigid bodies will be baked using Position, Scale and Rotation sequences only, while soft bodies will have a PLA sequence assigned.

Bake Solver

Bakes the selected object's Solver, including all rigid bodies and soft bodies.

Bake All Solvers

This function will bake all Solver objects in the scene, including their rigid bodies and soft bodies.

Clear Solver

If you have previously baked a solver, the Timeline will contain the corresponding animation tracks. With this command you can delete all tracks for the current Solver object.

Clear All Solvers

This command will delete all animation tracks for all Solver objects in the scene.

Tips and Tricks

Get into the habit of setting the viewport frame rate to All Frames. To do this, click this icon in the Time palette.

A menu will appear. On this menu, enable the All Frames option if it isn’t already enabled. This will ensure that each frame in the dynamics animation will be played in the viewport, thus guarding against dropped frames.

Frequently Asked Questions

No matter how many time you read the manuals (you have, haven't you?), there will always be questions that pop into your head. In this section we try to anticipate some of these — FAQs can be a valuable resource to supplement your understanding.

▸ **Why isn't the movement in the viewport smooth?**

The viewport playback speed is entirely dependant upon your CPU speed and the complexity of the simulation.

If you are simulating orbiting planets, say, you should be able to sustain a reasonable 25 or 30 fps on almost any computer. However, if you have designed a detailed scene with many physical objects and full collision detection, expect the frame rate to slow down. Also, don't expect speedy results if you have loaded an existing scene and simply added some dynamics; it is far more efficient to design a dynamics simulation from scratch.

Here are some tips:

Try to limit the number of polygons in the scene as much as possible.

Use a strong negative gravity field instead of collision detection where possible.

For soft bodies, rather than using an object with a high polygon count, try using one with a low polygon count and dropping it inside a Hyper NURBS object; this way Dynamics has to run its calculations only on the low polygon object.

Enable OpenGL; this will free up your processor to calculate the physics while the display of your simulation is handled by the graphics card.

▸ **How can I make a sail that will move a yacht when the wind blows it?**

To create a yacht's sail you will need to use soft bodies.

First of all create your sail and mast, then add the soft body and rigid body tags to these. The easiest way to attach the sail to the mast is by using rigid springs; if you make these very short and very stiff they will act like a short piece of rope connecting the sail and the mast together. We recommend that you use the RBS Draw Tool to connect the springs between the edges of the sail and the mast.

Depending on the type of sail you want to create, you may only want to pin the sail at three or four points or you may want to have regular ties all along the mast to keep the sail attached firmly. Using many springs to connect the sail will give pleasing taught ripples through it as the wind blows.

▸ **Why do the objects penetrate each other when colliding?**

No object in the world is perfectly rigid. By allowing objects to penetrate each other slightly you will give the impression that they are actually deforming under the collision, which can give a natural look. However, this is not what you want if you are using very thin, or transparent, objects.

To achieve more rigid collisions you may wish to increase the Oversampling value in the Solver object. This will cause more frames to be calculated between each real frame, increasing the chances of a 'correct' collision. Alternatively, increase the Eps value; this will enlarge the object's collision boundaries so Dynamics will think that the objects have collided slightly earlier.

▸ **Why do the objects levitate?**

If gravity is present in your scene and you have the camera positioned exactly side-on to an object on a perfectly flat surface, you may see that it is actually hovering very slightly above the surface.

This is due to the Collision Eps value of the Solver (in the Details tab), which determines how close objects must be before they are considered to be touching. Reduce this value to allow the objects to get closer together.

▸ **How can I make a brick wall and then knock it down?**

One of the difficulties in setting up a brick wall is getting the bricks to keep still before they are knocked down.

You could arrange the bricks so that they have a small gap between them, this gap being the same size as the Collision Eps value in the Solver. Alternatively, you could drop the bricks onto each other and initialize the scene once they are at rest. This will then start the simulation with the bricks in this state.

How you knock down the wall is entirely up to you!

▸ **Why does the scene explode and/or objects disappear?**

If you find objects suddenly disappearing into the distance or soft bodies violently rippling then it is likely that your Solver Object's integration method is set too low.

The level you need for the Integration Method largely depends on the relative speeds of the objects controlled by the Solver. For example, a dart hitting a dartboard hits it at a relatively high speed; this means that you need a very accurate solver to make sure it stops when it reaches the board.

► **I have no idea what values to use for the friction coefficients.**

Here is a useful list of friction presets that is not intended to be physically accurate but should achieve the effect you want:

	Dynamic coefficient	Static coefficient
Shoe on carpet	70%	95%
Shoe on ice	20%	20%
Shoe in grass	50%	65%
Tire on dry Tarmac	95%	98%
Tire on wet Tarmac	75%	97%
Tire in ice Tarmac	30%	80%
Puck on air hockey table	5%	5%
Brick on concrete	80%	90%
Soap on enamel	10%	50%
Football on grass	55%	65%

You can use static coefficient values over 100% to simulate a very coarse, or ribbed surface, such as polystyrene or a stony surface.

► **Why do I get different results for the same scene on the Mac and the PC?**

This is an inherent problem of using cross platform software. Macs and PCs both use very different processors and the FPU (Floating Point Unit) varies between them. This can often give slightly different answers to the same calculation because of the differing rounding algorithms and precision used.

So, if a pinball hits a flipper and bounces off, the Mac may calculate the ball has left the flipper at one angle and the PC may come up with a different value. This may be a fraction of a degree. However, by the time the ball reaches the top of the table, it could mean the ball hitting a completely different part of the table. As the simulation continues, the ball ends up taking a vastly different route. For this reason you may wish to bake your simulation or use a network that has only one type of processor in it.

► **Why does the cloth look like rubber?**

The most likely cause of this is that the springs are too stiff and have a low density mesh. The default cloth springs use all three types of spring: structural, flexion and shear. The flexion springs can stop the material from creasing like cloth usually does.

If you have a cloth with few subdivisions the flexion springs will spread themselves quite widely and, because they only link to every other point, they cannot then fold. To get around this you can either remove the flexion springs altogether or use a finer mesh for the cloth.

▶ **Why does the cloth fall apart when I use only shear or flexion springs?**

If you take a closer look at these two types of springs you'll notice that they are all criss-crossed. Both types of spring actually consist of two layers of springs that are in no way connected. This means that if you grab the cloth by setting a single point to have a mass of 0, then only one layer of springs will be held whilst the other layer is allowed to fall. So the answer here is to add some structural springs.

▶ **How can I connect a rigid body to a soft body?**

Currently the only way to fix a rigid to soft body is by using a Rigid Spring tag.

▶ **Why do I have to initialize the scene?**

Dynamics simulates movement starting from an initial set of values; subsequently everything happens automatically. The scene needs to be initialized because Dynamics modifies the position, rotation and shape of objects independently of CINEMA 4D's object system.

Suppose you've played a simulation through a few frames. What will happen now if you pause the playback and move an object? Should the object start its animation from that position the next time you play the scene? You can see that it is important that Dynamics' position and rotation data is held separately from CINEMA 4D's data.

Scene and object initialization is done automatically where possible (such as when you drag an object into the Solver). You should only need to initialize the scene when you manually change the starting positions.

▶ **Why can't I blow part of a rigid object to spin it?**

All forces such as wind, gravity or drag will only affect an object whose centre of mass is inside the field and these forces will affect the entire object. This means you can't blow, say, half a page of paper to make it spin; the paper will move linearly in this case. In certain cases it may be possible to use a drag field.

▶ **My simulation is nice, but takes too long to calculate. How can I speed it up?**

This is usually a scale problem.

Suppose you've created a scene of a ball falling on a plane. It would appear to behave completely differently if you used a 100 m wide ball than if you used a 1 cm wide bouncy ball (parallax). The easiest way to adapt this behavior is to increase the gravity strength. Increased gravity will cause objects to fall more quickly and this is often enough to make the simulation run as you expected.

- **The objects don't react when they collide with each other. What's going on?**

  This is likely to happen if you have scaled an object using the Object tool; Dynamics does not work correctly with objects that have had their system scaled. You will need to select the object and choose Functions > Reset System to return the object to the correct scale. You may then use the Model tool to scale the object as you need it.

- **Why do highly damped rigid springs explode?**

  Spring damping uses a similar algorithm to the drag object and you will notice that too much drag will cause objects to gain energy in an uncontrollable way. This sounds counter-intuitive but is due to the fact that if you try to remove too much energy from a system in a short space of time some of the objects will try to continue at high velocity, destabilizing the system. This also affects soft body springs.

- **I have an object at an angle. Why don't the start values make it move in the direction it is pointing?**

  All Dynamics objects work using the world coordinate system, not the object's local coordinates. The only exception to this is constraints, which use the coordinate system of the parent object.

- **Why does the console say 'Maximum number of contact points reached!'?**

  This message is telling you that Dynamics has exceeded the maximum number of points that it can simultaneously calculate for collision detection.

  This will often not influence the scene in any noticeable way. If you see this message and notice an object has not collided when it should, try reducing the collision type from Full, or try using a proxy object.

- **Why are the objects jittering and sliding when they should have come to rest?**

  This is most likely caused by having inappropriate Solver settings. It is generally recommended that you use the Midpoint integration method for simulation with collision detection. Enabling Energy Loss and Collision Use Rest Speed will also help.

- **When a soft body collides with a rigid body, the rigid body pokes through the cloth. How can I stop this?**

  This is due to the different ways in which collisions are calculated between soft and rigid bodies. Soft bodies do not have collision detection along their edges, only their points may collide.

  Increasing the Collision Eps setting on the Solver's Details tab will give the colliding objects a 'thicker collision skin' and will therefore help solve this problem.

► **Why has the object stopped moving?**

It has hit something.

Gravity has stopped it.

The Solver has some Energy Loss.

It has entered a strong Drag field.

The scene is processor intensive and has caused the frame rate to drop dramatically.

Your Solver is still set to work for the default 75 frames.

► **How can I create falling leaves?**

It depends on how much detail you want them to have.

In reality leaves are soft bodies but they are usually so light that they will not deform when they are blown about and hit other objects. This means you can often get away with using a rigid body for the leaf in Dynamics.

If your leaves are just one polygon thick make sure you have Double-Sided enabled (Rigid Body tag, Aerodynamics tab) so that they can be blown no matter which way they face.

► **How can I create hair?**

You can make soft and flexible hair by creating a long ribbon shape and turning it into a soft body. Then use an alpha map on the object to give the impression that it has many hairs. Self collision detection can be used to prevent the hair from passing through the body and itself.

► **Why do I have to use polygon or spline objects in Dynamics?**

All objects must be in a polygon form for Dynamics to work; this is because parametric objects contain no real geometry for the Dynamics engine to work with.

A spline object may be used as a soft body because it is only the points that matter when soft body calculations are made by Dynamics.

CINEMA 4D

Release 9

Index