DMM TUTORIAL 4: Setting Physical Materials

An important element of creating and using DMM is setting the physical material properties of DMM objects. DMM Physical Materials have nothing to do with Maya surface materials. A Physical Material is a set of parameters that control how a simulated object behaves.

DMM is based on the science of continuum mechanics and finite element theory, therefore, the parameters that govern DMM's actions are exactly the same as what you might find in a materials science textbook.

A library of materials is included with the plug-in. These have been created to mimic real world objects' behaviors. But by adjusting the different parameters, it is also possible to create objects that cannot exist in the real world due to the physical constraints or reality.

In this tutorial you will use the DMM scene created in Tutorial 3 and

- Modify the final simulation just by changing the DMM materials
- Modify different parameters of a material to understand what they control

Changing the DMM materials

In tutorial 3, you modified the DMM materials of the objects. What if you hadn't done so? What would the simulation have looked like? Lets reapply the DMM default material to see what happens:

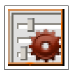
1. Open your scene. (If you don't have this scene anymore you can use the *tutorial4_start.ma* file which is provided here.)
2. Select the hammer
3. Select *DMM Material / Assign Existing DMM Material / defaultDMMMaterial1*
4. Select the chair
5. Select *DMM Material / Assign Existing DMM Material / defaultDMMMaterial1*
6. Play the simulation. You can see that the objects are totally soft and bounce around like rubber. Not exactly the effect we were going for!
7. Try applying different materials to your objects to see how that changes the simulation. (An iron hammer with a crystal chair for example)
   - Select the object
   - Select *DMM Material / Assign New DMM Material /* whatever material you want

You might also wonder why we applied a concrete material for the hammer instead of a wood one in tutorial 2. It was to make sure the hammer was stronger than the chair so that it would break it. There is a better way to do this by changing the material's parameters: we could have increased the toughness of the hammer's wood material.

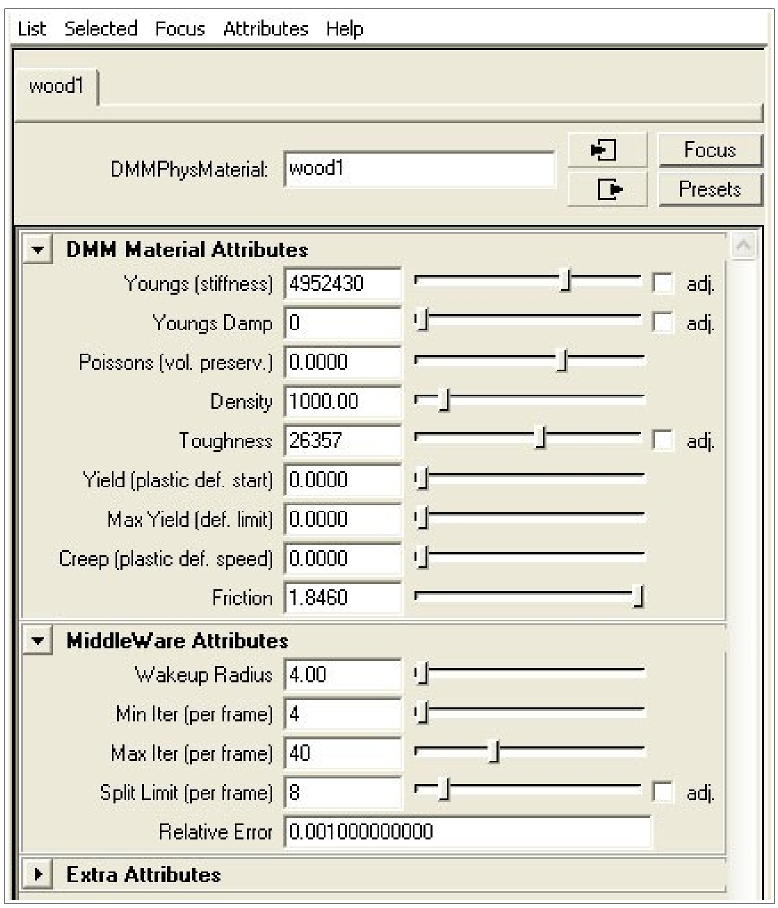
Editing the DMM Material's parameters

You may want to create a material that does not exist in the library. Generally, the best place to start in creating a DMM material is to edit an existing material that has a behavior close to your target material.

Lets try to modify our *wood1* material into a very breakable kind of wood for the chair and create a wood2 material for the hammer which will be much heavier and harder.

1. Reapply the wood1 material to the chair
   - Select the chair
   - Select *DMM Material / Assign Existing DMM Material / wood1*
2. Apply a wood2 material to the hammer
   - Select the hammer
   - Select *DMM Material / Assign New DMM Material / wood*
3. Play the animation. You can see that the hammer isn't strong enough as it bends when it hits the chair.
4. Select the *DMM Material Node* of the chair to view it's attributes in the Attribute Editor
   - Select the chair
   - In the *DMM Asset Manager* click on the *Select* button next to *DMM Material Node* or select 

Here is what you will see in the Attribute Editor:



Before modifying them, let's examine what all these different parameters control.

Youngs (Young’s modulus of elasticity) Controls how stiff a material is. Larger values mean stiffer, smaller values mean more elastic. Ranges from 0.1 to 1e10. It is important that *Youngs* always be greater than *Youngs Damp*.

Youngs Damp (Youngs Dampening) It is a dampening value related to velocity. Describes how much energy the material dissipates as heat when subjected to a sudden force. Ranges from 0.1 to 1e9. It is important that *Youngs Damp* always be less than *Youngs.*

Poissons (Poisson’s Ratio) Specifies the amount of volume preservation a material has when subjected to stress. Zero means perfect volume preservation, positive values mean volume increases when stretched, negative numbers mean volume decreases when stretched (cartoon like)

Density How many kilograms per unit volume the material weighs. Ranges from 1 to 10,000. Increasing this number without increasing toughness can result in objects that collapse under their own weight.

Toughness How strong a material is or how easily it fractures. Bigger numbers are tougher. 0 is a special case: it makes the object unbreakable.

Yield (Plastic deformation start) How far the material must deform before it stays deformed. Ranges from 0 to 1.

Max Yield (Deformation limit) Maximum amount of plastic deformation beyond which it will spring back. Ranges from 0 to 1.

Creep (Plastic deformation speed) How fast a material can plastically deform (deform and stay deformed). Ranges from 0 to 1.

Friction (Coefficient of dynamic friction) Smaller numbers are more slippery. Ranges from 0 to 0.5.

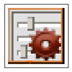
Wakeup Radius Radius of nodes around an impact point in which Tets will be woken up if the object is frozen. Reducing Wakeup Radius can create materials that act very rigid except in areas where forces are applied. Care should be exercised, as increasing the wakeup radius too much will wake up too many things resulting in slowdowns.

For more information on DMM Materials see the **DMM User Guide** and the **DMM Material Help** (Select *DMM Help / User Guide* or *DMM Help / DMM Material Help*)

5. Change the wood1 parameters to
   - Youngs: 5'500'000
   - Toughness: 2000
6. Select the *DMM Material Node* of the hammer (wood2)
   - Select the hammer
   - In the *DMM Asset Manager* click on the *Select* button next to *DMM Material Node* or select 
7. Change the wood2 parameters to
   - Youngs: 100'000'000
   - Density: 3000
   - Toughness: 20'000

Play the animation. You can see that the hammer doesn't bend anymore and the chair breaks.

You can now try changing different parameters for wood1 (the chair) to see how each one affects the simulation.

8. Select the wood1 *DMM Material Node*
   - Select the chair
   - In the *DMM Asset Manager* click on the *Select* button next to *DMM Material Node* or select 
9. Change the Toughness parameter
   - to 500 : the chair breaks very easily.
   - To 10'000: it does not break anymore.
   - Back to original value of 2000.

Note: Toughness = 0 is a special value. The material is then unbreakable.

10. Change the Youngs parameter
    - to 100'000: the chair is now elastic. It can't even stay on it's feet!
11. Change the Poissons parameter
    - To 0.4900 : the chair's volume changes, it stretches when it bounces. (If you cannot see this you can try applying the wood1 material to a cube DMM primitive and letting it fall to the ground. The difference might be easier to spot).

Changing materials during a simulation

It is also possible to animate DMM Materials. For example a magician could make your hammer go soft, making it impossible for you to break the chair!

1. Reapply the original wood1 parameters to the chair:
   - Youngs: 5'500'000
   - Poissons: 0.0000
   - Density: 1000
   - Toughness: 2000
2. Select the hammer
3. Add key frames (frame 40 and 60) to make it hit the chair twice.
4. Select it's material node.
5. In the Maya Channel Editor make a key frame for the Youngs parameter (100'000'000) at frame 0 and 30.
6. Go to frame 55 and change the Youngs parameter to 500'000. Key frame it.
7. Play the animation for 70 frames.
   - You can see that the hammer first hits the chair and almost breaks it, but the second time it has become all soft.