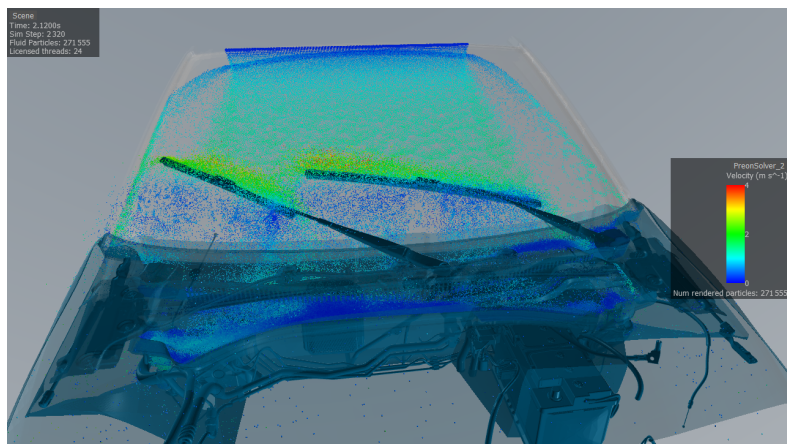


Beginner Tutorial 4.2.0


Rain Management Example



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1 About

This beginner's tutorial teaches the basics of PreonLab. You will learn how to work with the user interface and the various controls by setting up an example simulation for rain management.

For more information beyond this tutorial, please refer to the PreonLab user manual or advanced tutorials on [PreonAcademy Tutorials](#). Alternatively, hovering over particular elements in PreonLab with your mouse shows a tooltip with additional information.

Prerequisites:

- PreonLab 4.0 or newer is required in order to complete this tutorial yourself. To download PreonLab and its user manual, visit [PreonLab Downloads](#).
- Supplementary files for this tutorial. Please download these from [PreonAcademy Tutorials](#), section Rain Management Example.

2 User Interface

To get started with PreonLab, you should become familiar with its most important elements. This chapter gives you an introduction into PreonLab's user interface. For a detailed description refer to Chapter 3 of the manual.

2.1 Overview

PreonLab consists of different widgets to set up and modify scenes. A scene is built with objects and parameters which ultimately simulate dynamic behavior. Figure 1 shows the startup window of PreonLab and names its most important components.

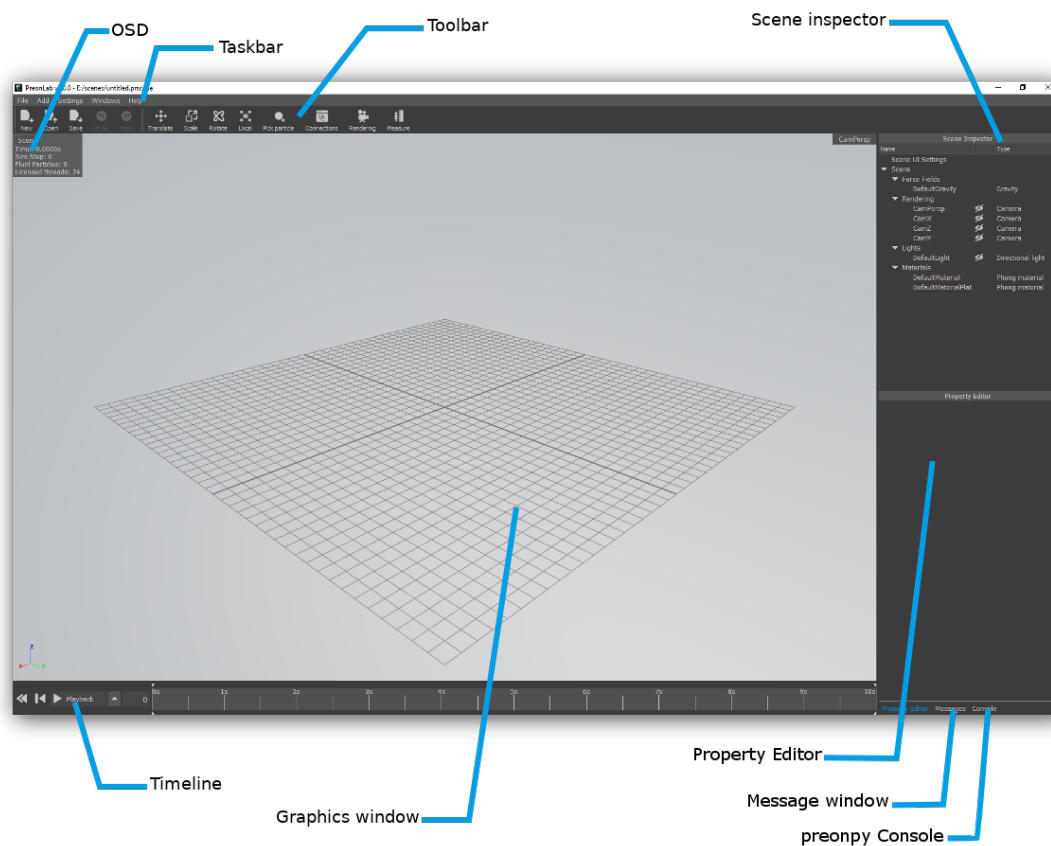


Figure 1: User Interface Overview

2.2 Add menu

To add a new object to a scene, use the *Add* menu in the taskbar. Figure 2 shows the *Add* menu in detail with different categories of objects that PreonLab supports. Note that importing predefined meshes from files is done using *File*→*Import*→*Import Mesh* or by using drag-and-drop. This is explained in more detail in Section 5.1.

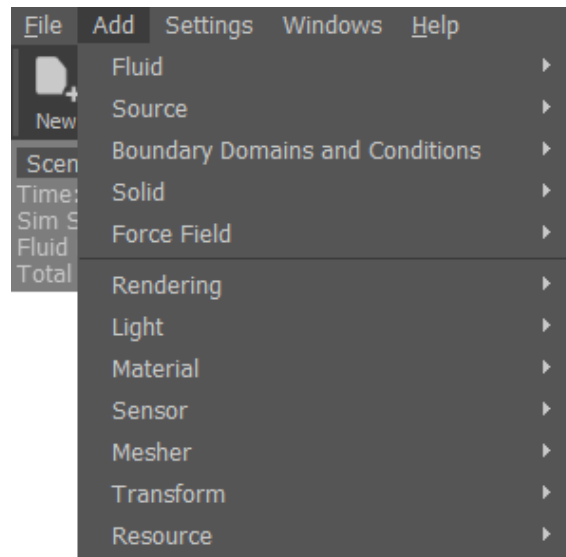


Figure 2: Add Menu

2.3 Toolbar

In the toolbar, you can find several tools to modify a scene or an object. Figure 3 explains them in detail. To activate a tool, simply click on its icon. The toolbar is context-sensitive which means that it shows different tools for different selections.

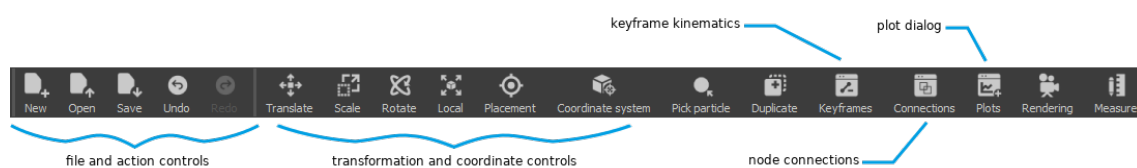


Figure 3: Toolbar

2.4 Graphics window

The graphics window shows the 3D view of the scene. Figure 4 shows the graphics window for a new scene.

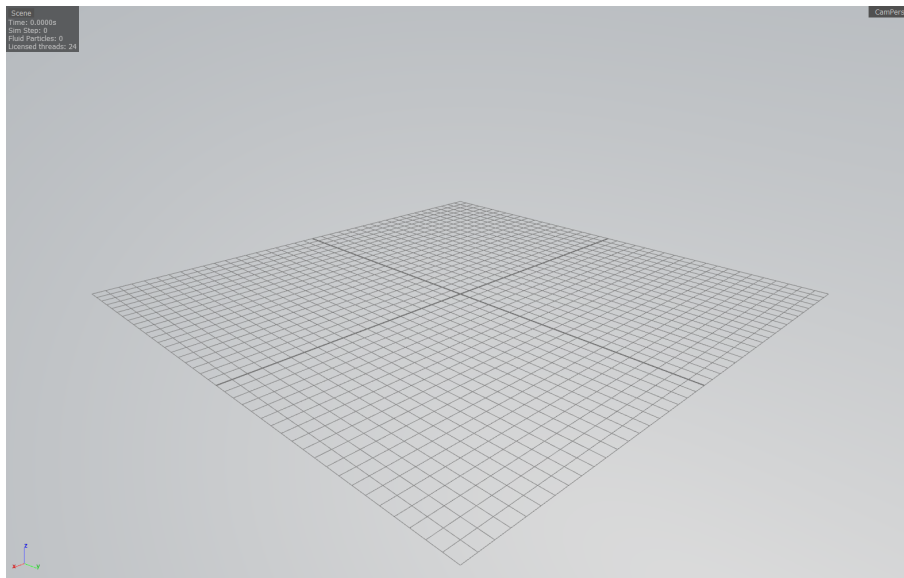



Figure 4: Graphics Window

2.5 On-screen display

The on-screen display (OSD) shows statistics of specific objects in the scene. You can expand or collapse the displayed information by clicking on the field with the object's name. Figure 5 gives an idea of how that might look.

2.6 Scene Inspector

The Scene Inspector summarizes all objects in a scene. Once one or more objects are selected, the Property Editor shows additional properties and parameters of the selected object(s) which can be modified, see Figure 6. Objects with property **Appearance**→**render mode**→**invisible** get an  icon and are not displayed. An object with property **General**→**behavior**→**inactive** is printed in **brown** letters and is ignored in both simulation and post-processing.

2.7 Property Editor

Properties which deviate from their default value are printed in **bold** letters which also applies to all property groups they are a part of. Right-click and select *Set to default value* to reset the property. Keyframed properties are recognizable by a **green** (displayed value is a keyframe), **yellow** (displayed value is interpolated from keyframes) or **red** (displayed value is ignored in favor of keyframes) background, refer to Chapter 6 in the manual for keyframing or advanced tutorials.

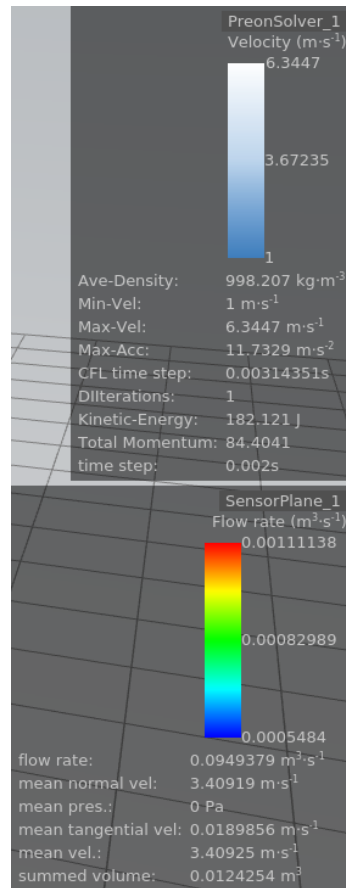


Figure 5: OSD (On-Screen Display) example

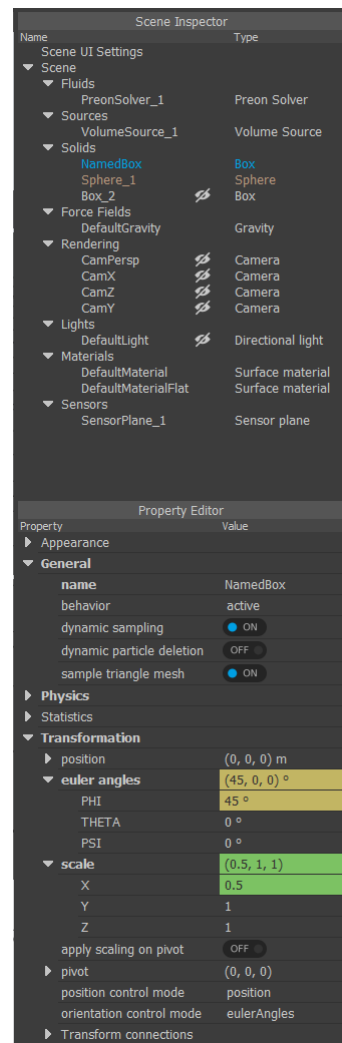


Figure 6: Scene Inspector and Property Editor

2.8 Timeline

The timeline is used to control simulation and playback of a scene. In Figure 7, the blue bar indicates the time range in which the scene has already been simulated.

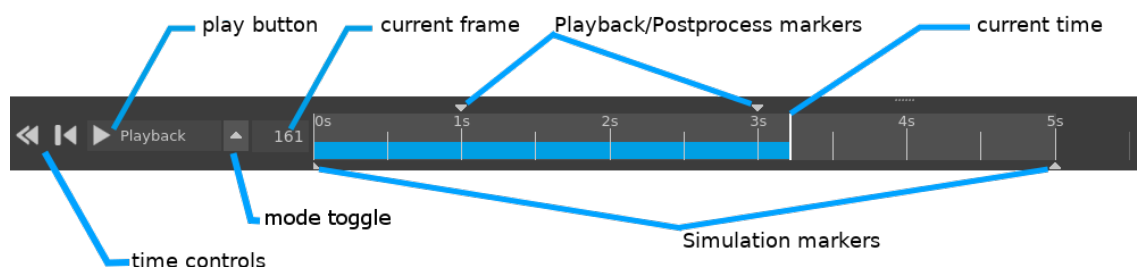


Figure 7: Timeline

3 Controls

In the following two tables, the most important mouse controls and keyboard shortcuts are listed. These controls should be enough to complete this tutorial.

For additional controls, please refer to the PreonLab manual.

3.1 Mouse

Control	What it does
left click	Select object under mouse pointer.
CTRL + left clicks	Select multiple objects.
mouse wheel, or right mouse button + mouse move	Zoom in and out.
control key + left mouse button + mouse move	Rotate the camera. By default, the control key is SHIFT. This can be customized via the taskbar <i>Settings</i> → <i>User Preferences</i> .

Table 1: A list of mouse controls in PreonLab.

3.2 Keyboard

Key	What it does
w	Enters / leaves translation mode.
e	Enters / leaves scale mode.
r	Enters / leaves rotation mode.
DEL	Deletes the selected object(s).
CTRL + s	Save current scene.

Table 2: A list of some of the keyboard shortcuts in PreonLab.

4 Engineering problem description

The objective of the example simulation is to assess and optimize the flow paths and flow rates inside the engine compartment in a heavy rain situation. It corresponds to an actual experiment set-up. While the basic set-up will only assess the results for an off-state vehicle, the enhanced set-up will also consider the stationary air flow caused by the HVAC (Heating, Ventilation and Air Conditioning) system and the wiper kinematics. The latter matches a traffic jam situation.

The inlet in the actual experiment is a flat nozzle with the following specifications:

- continuous flow rate of $Q = 2 \text{ L/s}$
- width: 0.015 m, length: 0.8 m
- located at the top of the wind shield

Analysis objectives:

- Is the drainage concept appropriate?
- Is it still appropriate with respect to wiper movement?
- Will water enter the HVAC system?

5 Setting up a basic scene

Let us start with setting up a very basic scene before enhancing it to a more extensive simulation. In each of the following steps you can always compare your result with the desired result by opening the corresponding scene in the *ComparisonScenes* folder.

We will import rigid body surfaces into PreonLab and specify the import unit so they have the desired size. By using a clipping object and transparency, you will have the chance to see inside the imported meshes without removing any part of the exterior. With a continuous fluid source and a solver, we will prepare a simulation of a flowing stream of water interacting with the imported meshes in a restricted simulation domain. This will represent the basic problem described in Chapter 4. After setting up our scene, we will start the simulation.

5.1 Import meshes

While you can add basic shapes manually via the *Add* menu, see Section 2.2, often times you want to import predefined meshes from other files.

Start PreonLab to have a new and empty scene ready like in Figure 1. Locate the *.stl* files in the *Materials* folder that came with this tutorial. Select all of them, then drag and drop them into PreonLab with your mouse all at once. An *Import Mesh* dialog now opens and provides different options for importing the meshes. You can for example change the unit of the imported meshes. For now, leave everything at the default value and click on *Import*. In the Scene Inspector, you should now see 9 **Meshes** in the category *Solids* and corresponding **Mesh resource** entries in *Resources*. The **Mesh resources** specify the files on disk from which the meshes are loaded and the **Meshes** are solids which carry the physical properties.

5.2 Save the scene

It is always recommended to save the current state of your work frequently.

Choose *File*→*Save as* in the taskbar (compare Figure 1). Remember or adjust the folder shown in the file browser, this is where your scene will be saved. To get a self-contained simulation directory, all external resource entries need to be exported. If the dialog does not default to all external resources checked, check the box *External*

Resources at the top. Your dialog should look like figure Figure 8 (for more information, see Section 17.1 in our user manual). Enter a name for your scene and press *Save*.

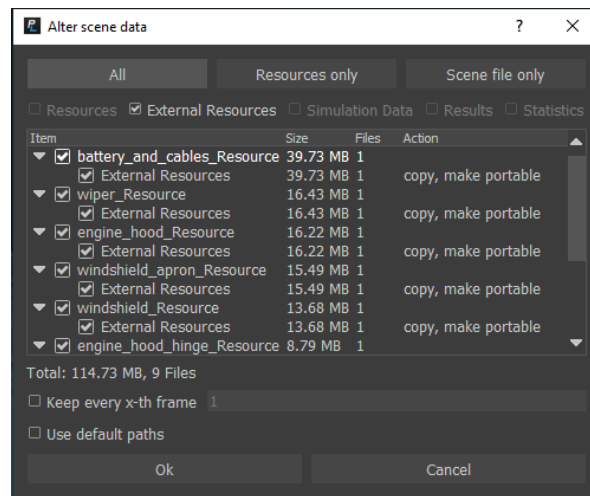


Figure 8: Save as - copy scene data dialog. Selecting all external resources will copy the mesh resource files into the created scene folder.

Once you have saved your scene to a specific file, a simple *File*→*Save* or **CTRL + S** is enough to overwrite the old saved state with the current state of the scene.

After this step, your saved scene corresponds to the scene *rain_management_1.prscene* in the *ComparisonScenes* folder.

5.3 Clipping object

Very often you want to see inside an object but the view is blocked by its exterior.

Choose *Add*→*Rendering*→*Clipping object* to add a **Clipping object** to the scene. Now, zoom in with your camera and translate/rotate both your camera and **ClippingObject_1** so you can see inside the engine compartment like in Figure 9. For help with adjusting your camera, see Section 3.1. For translation and rotation tools, see Section 3.2 or Section 2.3.

Note that the clipped parts are only visually removed. Physically, the meshes are still complete in the simulation. After saving, your scene should be similar to the comparison scene *rain_management_2.prscene*.

5.4 Transparency

Besides clipping objects, PreonLab offers another way to see inside an object without removing any part of the exterior.

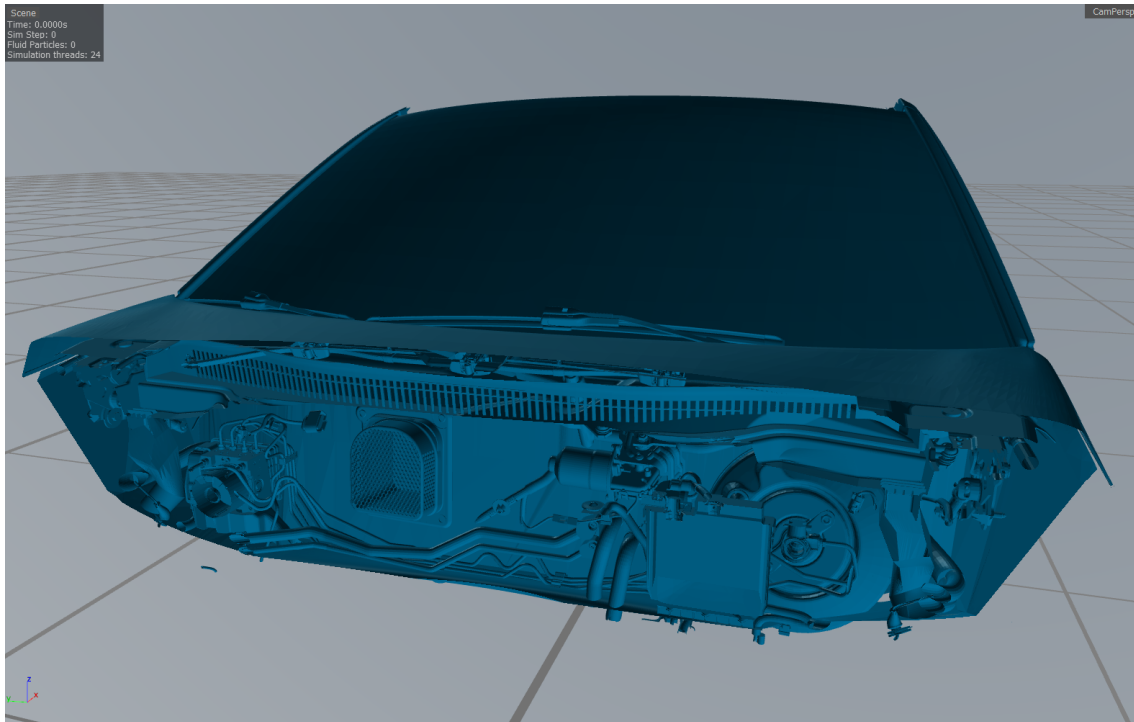


Figure 9: Clipping object reveals the inside of an engine compartment

Remove **ClippingObject_1** from your scene by selecting it and pressing the **DEL** key on your keyboard, or in the Scene Inspector *right mouse click*→*Delete*. Select the object **engine_hood**, then hold **CTRL** and click on **cover** and **windshield_apron** in the Scene Inspector. Change **Appearance**→**opacity** to 0.3 in the Property Editor. Again, feel free to adjust your view on the scene to inspect the different parts of the car.

Save the scene. This corresponds to *rain_management_3.prscene*.

5.5 Area source

With PreonLab you can emit fluid either as a volume or continuously from an area.

To simulate the problem described in Chapter 4, choose *Add*→*Source*→*Area source*. In the Property Editor, open the groups **Transformation**→**scale** and **Transformation**→**position**. Considering the specifications from Chapter 4, adjust the properties to:

- **scale**→**X** set to 0.015
- **scale**→**Z** set to 0.8
- **position**→**X** set to 0.9 m
- **position**→**Z** set to 1.05 m

Observe how the source is moved to the top of the wind shield. Also change **Set-**

tings→inflow unit to **volumeFlowRate**. Additionally, set **Settings**→**volume flow rate** to $0.002 \text{ m}^3/\text{s}$ which equals 2 L/s .

The scene should now correspond to *rain_management_4.prscene*.

5.6 Solver

Whenever you want to simulate fluid behavior with PreonLab, you need a **solver**.

Choose **Add**→**Fluid**→**Preon Solver**. In the Property Editor, edit the following property:

- **General**→**spacing** to 0.0025 m . Accordingly, we have just defined a single fluid particle to have side length of 2.5 mm .

The default settings of the Preon solver are parametrized for water, i.e., rest density is 998 kg/m^3 and cohesion 0.072 N/m so we don't need to change the other properties for this tutorial. The solver properties are detailed in the PreonLab user manual. However, it is often required to parametrize the physical interaction of the fluid with solid geometries, particularly the adhesion factor with which you can control the wetting angle, see **Physics**→**adhesion** property of solid objects.¹ For this example scene, we can just keep the default values. To learn more about solid-fluid interaction in PreonLab, please refer to the manual and to the Preon solver theory document.

This state of the scene should match *rain_management_5.prscene*.

5.7 Simulation domain

Typically, in a simulation, you are only interested in what happens in a limited space. Therefore, in PreonLab, you can restrict the simulation domain which in most cases improves the computation time significantly.

Choose **Add**→**Boundary Domains and Conditions**→**Box domain**. Per default, the **Box domain** deletes all particles outside of the domain. Please refer to the chapter Boundary Domains and Conditions in the PreonLab manual to learn more about the different options and capabilities of domain objects. Feel free to translate and scale the box yourself so it barely encapsulates all objects in the scene (for translation and scale tools, see Section 3.2 or Section 2.3). Alternatively, you can use the following values for your **BoxDomain_1** in the Property Editor:



- **position**→**X**: 0.37 m
- **position**→**Y**: 0 m
- **position**→**Z**: 0.68 m

¹Note that the adhesion property of the Preon solver scales the adhesion of this fluid to other fluids in the scene, but not to solids.


- **scale**→X: 1.6
- **scale**→Y: 2
- **scale**→Z: 1

Save the scene. It should now correspond to *rain_management_6.prscene*.

5.8 Simulate

We have finished a basic scene set-up that we can simulate properly. In the timeline, switch to the simulation mode by pressing the mode toggle  and selecting *Simulate*. Then click the play button . Observe how the fluid particles slide down the wind shield and make their way through the engine compartment. You should see that they are guided through a drainage and exit the engine compartment at the bottom. Again, feel free to adjust your view on the scene to inspect the simulation from different angles.

Note, that after not moving your mouse over the graphics window for 10 s, the graphics window will go into sleep mode and will not redraw itself as frequently to increase performance.


You can always stop simulating by pressing the play button again which shows a pause symbol while the simulation is running .

6 Enhancing the basic scene

With the basic scene set-up in Chapter 5 we have successfully simulated an off-state vehicle. In this chapter, we will enhance the basic scene with additional external forces and kinematics to cover the advanced problems from Chapter 4.

6.1 Drag force

By default, scenes in PreonLab only have gravity acting on fluids. However, you can add several forces to compensate for other external forces in the real world.

Enhance the scene from Chapter 5 by choosing *Add→Force Field→Drag Force*. Set **General→air velocity→y** to 20 m/s. Go to the beginning of the simulation by clicking on the far left of the timeline where 0s is written. Alternatively, you can enter frame 0 in the *current frame* input in the timeline .

The scene should correspond to *rain_management_7.prscene* now.

Start the simulation again. The wind modeled by the drag force should now push the fluid particles to the side in positive y-direction.

6.2 Air flow

While drag forces only act in one direction in PreonLab, you can also add multi-directional air flows to your scene. The multi-directional air flow data can be provided to PreonLab via a CSV file. For the current scene, download *AirflowData.zip* that comes as a supplementary file of this tutorial, and extract the contents.

Jump again to the simulation start. Remove **DragForce_1** from your scene (detailed instructions in Section 5.4). Choose *File→Import→Import Airflow*. For the *Path* field, click *Browse*, locate and select the *air_flow.csv* file in the *Materials* folder that you just extracted, then click *Open*. The separator should be automatically detected as comma. Set the following values for the respective fields while leaving the others unchanged:

- *X-Position Name*: Vertex:0
- *Y-Position Name*: Vertex:1

- *Z-Position Name:* Vertex:2
- *X-Velocity Name:* Velocity:0
- *Y-Velocity Name:* Velocity:1
- *Z-Velocity Name:* Velocity:2

Click *Import* and wait a moment while PreonLab initializes the air flow. For **AirFlow_1**, set **Transformation**→**euler angles**→**PHI** to 90°, **Point cloud import**→**discard samples** to **FixedValue** and **Point cloud import**→**Discard Settings**→**max. vel. length** to 17 m/s.

Save the scene. It should now match *rain_management_8.prscene*.

6.2.1 Show Sample Points

CAREFUL: Your graphics card needs at least 4GB of memory for the next operation. You can inspect the result in Figure 10. Alternatively, an air flow visualizer is more memory efficient. You can skip to Chapter Section 6.2.2 to learn about it.

Set **Appearance**→**show sample points** to **On**. If you zoom in with your camera, you should be able to identify a three-dimensional vector field indicating the air flow. Figure 10 shows a cut-away view of it using a clipping object.

Set **Appearance**→**show sample points** to **Off** and simulate. The air flow should have a noticeable effect on the fluid particles.

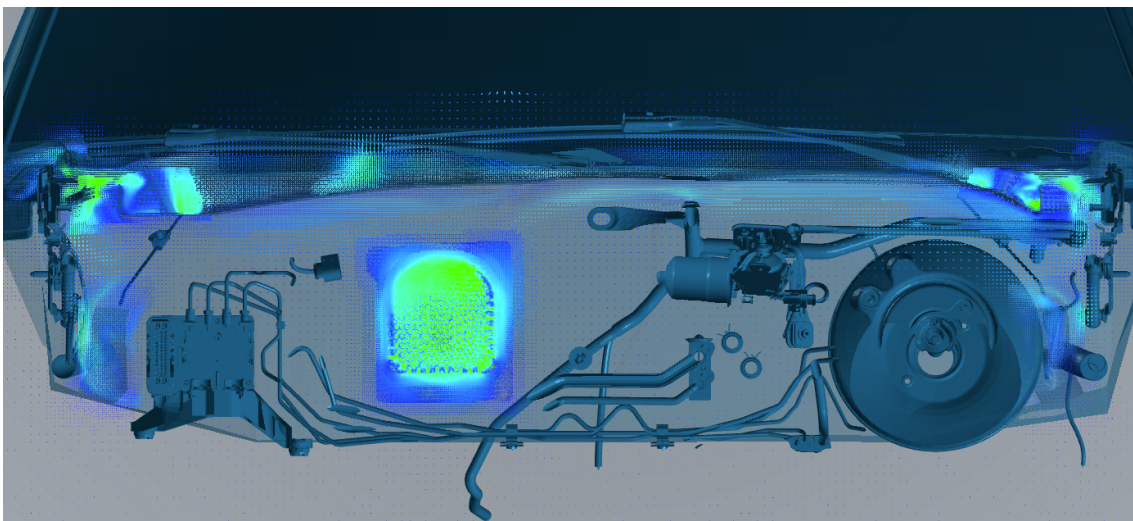


Figure 10: Clipping object reveals the regions affected by the air flow

6.2.2 Air Flow Visualizer

The air flow visualizer is another way of inspecting the air flow on a plane: Choose **Add**→**Sensor**→**Air Flow Visualizer**. Increase the **Transformation**→**scale**→**z** to 1.65 to match the width of the car. Rotate the visualizer into the y-z plane by setting **Transformation**→**euler angles**→**THETA** to 90°. Move the visualizer up with **Transformation**→**position**→**z** to align it with the engine room at 0.45 m. You may additionally scale it down to fit the air flow data by setting **Transformation**→**scale**→**x** to 0.6.

Click *Translate* in the toolbar. You can now click on the x-axis of the air flow visualizer to drag the plane back and forth to inspect the velocity magnitude. Figure 11 shows the air flow of some of the inner engine compartments using a clipping object.

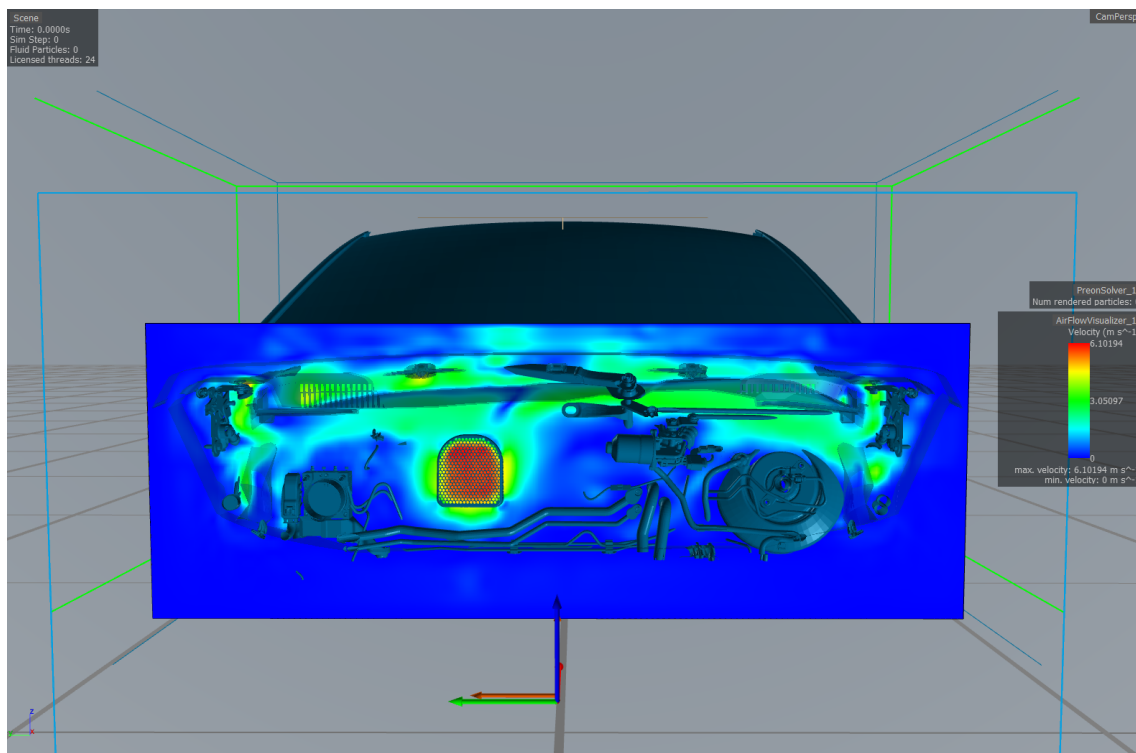


Figure 11: A clipping object is added slightly in front of the air flow visualizer to cut away obscuring geometry.

6.3 Kinematics

PreonLab supports the import of kinematics that have been prepared with other software.

Jump again to the simulation start. Remove the **wiper** object from your scene (detailed instructions in Section 5.4). Choose **File**→**Import**→**Import Animation**. For the **Path** field, click **Browse**, locate and choose the **kinematics** folder in the **Materials** folder that came with this tutorial. In the import dialog, enter **–10 s** in the **Start Time** field and click **Import**. Select the newly created **TransformGroup** and set **Transformation**→**euler angles**→**PHI** to 90° in the Property Editor.

This state corresponds to *rain_management_9.prscene*.

Simulate and observe how the wipers interact with the fluid particles.