The balloon

Gas law and elongation in materials

DynaLearn level 3 | Versie 0.9

Summary	
This lesson is about the Gas law. You will work with a computer model of a balloon filled with gas. The balloon is inflated. So, gas gets into it. The pressure and volume may then change. Also, the temperature can rise or fall. Next, we refine the model step by step. Finally, you will perform simulations and see what influence certain actions have on the outcome.	
Given name:	
Surname:	
class:	
Date:	
Comments by teacher:	

1. Introduction

This lesson is about the Gas law. You will work with a computer model of a balloon filled with gas. A balloon is inflated. So, gas gets into it. The pressure and volume may then change. Also, the temperature can rise or fall.

Next, we refine the model step by step. Finally, you will perform simulations with the model and see what influence certain actions have on the outcome.

Watch this video in which two people inflate a balloon: https://youtu.be/9JtxHWkrI-k

Figure 1. Inflating a balloon.

2. Starting DynaLearn

There are several ways to log in. Use one of the two options below. Then check whether the login was successful (see 'Let's check').

Via a code:

1. Go to DynaLearn (https://create.dynalearn.nl/).
2. Click on 'log in with code', at the bottom left.
3. Enter the project code and your (school) email address.
4. Copy the code from the confirmation email received from *dynalearn.nl* (see spam folder if needed) and fill in the other details.
5. Log in to DynaLearn.

By email invitation:

1. Copy the login details from the invitation email received from *dynalearn.nl*.
2. Go to DynaLearn (https://create.dynalearn.nl/).
3. Log in to DynaLearn.

Let's check!
After logging in, you will automatically enter in the white workspace of the assignment. You can recognize it by the question mark on the right side of the screen  . Is the question mark missing? Then first do the following:

- In DynaLearn, click  . Click on 'Select norm model'.
- Choose 'Gas law' and press 'Load'.

Save model file and start:

1. Click on  top left. Change the name to 'Gas law' and click 'Save'.
2. How do you proceed? Just follow the steps in this workbook. Note! You can't skip steps. Ask for help if you can't figure it out at a certain step. The video function  in DynaLearn shows how a model ingredient can be made. The boxes contain a brief explanation about the model ingredient. Put a check mark √ next to step you performed. This way you keep track of where you left off.

1. The quantities of Gas

1. Lees Box 1.

Box 1. Entity and quantity.

An entity is usually a physical thing in a system (e.g., car, human).

A quantity is a measurable property of an entity (e.g., temperature, length).

2. Make the **entity** *Gas* (see →).

3. Read Box 2.

Box 2. Help function.

If the question mark or an ingredient in your model is red, then something is wrong. Click the question mark for a hint. Then click on a number, for example 1 to see where the error is in your model. Only use the question mark if you can't figure it out yourself!

4. Gas has a number of relevant **quantities**, including *Temperature*, *Collisions* (of the molecules), *Pressure*, and *Volume.*
   - Add these **quantities** to the **entity** *Gas* (see →).
   - Notice the question mark. Correct errors before proceeding (see Box 2).

5. Read Box 3.

Box 3. Cause-and-effect relationships.

In DynaLearn, there are two types of cause-and-effect relationships:

- Positive relationship : the quantities change in the same direction (if quantity 1 increases, then quantity 2 increases also)
- Negative relationship : the quantities change in opposite direction (if quantity 1 increases, then quantity 2 decreases. Or vice versa: if quantity 1 decreases, then quantity 2 increases)

6. What are the **cause-effect** (or) relationships between the **quantities** of the gas? Which quantity influences which other quantity and is that a positive or negative influence? Suggestion: start from Temperature.
   - Make the three connections between the four **quantities** of the gas (see →).

7. Read Box 4.

Box 4. Change of a quantity.

A quantity can change. This is indicated by δ ▲ Ø ▼ . The delta symbol (δ) is the mathematical sign for change (also called the derivative). The down arrow (▼) is a decrease, the zero (Ø) is constant and the up arrow (▲) is an increase.

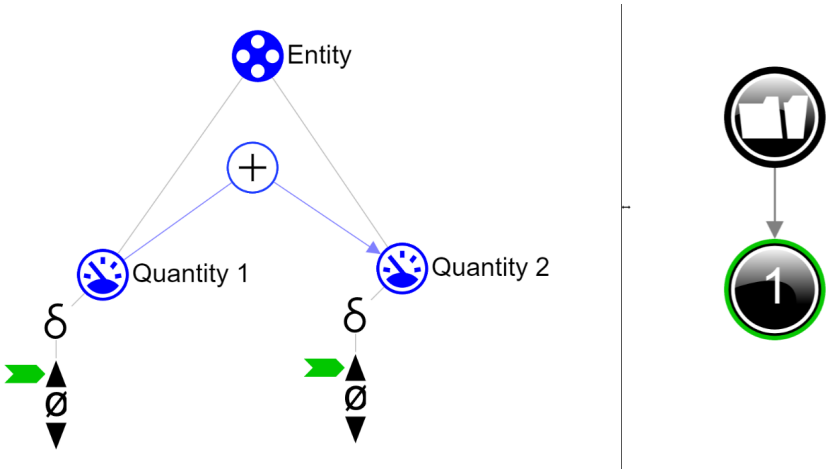
8. You can now run a simulation. To do this, you must first indicate an initial change. Start with an increase in temperature (see →).
   - Under entity Gas, for quantity *temperature*, click ▲ and choose . It should look like this:

9. Simulate your model by clicking on .

10. Read Box 5.

Box 5. Read the outcome of a simulation.

After starting a simulation (with), a window appears on the right in which the possible states of the system are indicated. There is one possible state in this example .



You can click on the state to view the outcome. The state icon then gets a green circle. In the model, the change for this state is indicated by green arrows . The model shows that in state 1 *Quantity 1* increases and that therefore *Quantity 2* also increases.

11. Make the sentence below correct. Cross out the wrong answers.

As *Temperature* increases, the number of Collisions decrease/increase. This will cause the *Pressure* to decrease/increase. Subsequently, the *Volume* of the gas will decrease/increase.

12. Click to align everything neatly. Click to make your model fit on your screen.

2. Gas is in Balloon

A gas is usually trapped in a 'container', for example a balloon. You are now going to add the balloon as a container for the gas. Of course, the balloon itself also has a few unique quantities.

1. Create a second **entity** and name it *Balloon* (→).

2. What is the relationship between entity *Gas* and entity *Balloon*?
   - Create a **configuration** between them that reflects this relationship (→).

3. For the *Balloon* we consider two **quantities**, namely *Volume* and *Stretch*.
   - Add these **quantities** to the **entity** *Balloon* (→).
   - Notice the question mark. Correct errors before proceeding (see Box 2).

4. What are the **cause-effect** (or) relationships between these **quantities**? Which quantity influences which other quantity and is that a positive or negative influence?
   - Create the **Cause-Effect** relationship between *Volume* and *Stretch* (→).

5. Changes in the gas have an impact on the balloon. Which one?

Write your explanation here...

6. Which **quantity** of *the Gas* influences which **quantity** of the *Balloon*?
   - Create the **cause-effect** relationship between the appropriate **quantity** of *Gas* and the appropriate **quantity** of the *Balloon* (→).

7. Run the **simulation** by clicking (upper right corner) and then view the outcome by clicking on (right hand side, halfway the screen).

8. Make the sentence below correct. Cross out the wrong answers.

As the Temperature of the Gas increases, the Volume of the Gas decreases/increases and therefore the Volume of the Balloon decreases /increases. As a result, the Balloon is stretched less/more.

9. Click to align everything neatly. Click to make your model fit on your screen.

3. Who is inflating the balloon?

The gas-balloon system is influenced by an *external* factor, namely the person who inflates the balloon.

1. Read Box 6.

Box 6. Agent.

An agent  is usually a physical thing with a measurable property that affects the system from the outside (e.g., government, sun).

2. Add **agent** *Human* to the model ().

3. Add the **quantity** *Inflate* to the newly created **agent** *Human.*

4. What happens if someone inflates a balloon? What is increasing in the balloon?

Write your explanation here...

5. In your model, add the **quantity** *Mass* to the **entity** *Gas*.

6. What are the four **cause-effect** relationships between the quantities *Inflate*, *Mass*, *Temperature* and *Collisions*? Please note, one relationship is already in your model.
   - Create the three missing cause-effect relationships.
   - Notice the question mark. Correct errors before proceeding.

7. Which quantity is at the beginning of the causal chain?

Write your explanation here...

8. Instead of the **quantity** *Temperature, make* the **quantity** *Inflate* increase.

9. Read Box 7.

Box 7. Help function.

If the explanation mark appears  , something is wrong during the simulation. Click on the explanation mark  for a hint. Then click on a number, for example  , to see where the error is in your simulation.

10. Run the **simulation** and inspect the result. Is the result as expected. Explain:

Write your explanation here...

4. The volume of a balloon is finite

A balloon cannot increase in volume indefinitely. At some point, the volume reaches its maximum size and the balloon snaps. You will now add a quantity space to the model in order to represent these details.

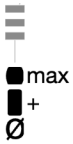
1. Read Box 8.

Box 8. Quantity space.

A newly created quantity does not yet have a quantity space. By adding a quantity space, you can indicate which values a quantity can take on. A quantity space consists of alternating points (■) and intervals (▮).

- A *point value* is only one value. For example, a *boiling point*. A special point is the zero point, for which there is a separate symbol (Ø) in DynaLearn.
- An *interval* is a set of values. The liquid phase of a substance is an example of an interval. In the case of water, the interval 'liquid' contains all values between 0 °C and 100 °C. The values 0 °C and 100 °C are respectively the 'melting *point*' and the 'boiling *point*' between which the interval 'liquid' is located.

2. Create a **quantity space** (see →) for the quantity *Volume* (of Balloon) with three values, namely: no volume (0), a range of possible volumes (+), and the maximum volume (Max). It will look like this:



3. Set the **initial value** on the lowest value of *Volume*, the value 0 (→).

4. Run the simulation by clicking and view the outcome, click on .

5. Increases **quantity** *Volume* now to the highest level? Are all the changes still being calculated?

Write your explanation here...

6. Go to the next assignment for explanation.

5. Keep inflating…

You can see that for all the quantities in state 3 the changes have disappeared; they are no longer increasing. This is so, because you have indicated that the *Inflate* increases at the beginning of the simulation, but not yet that *Inflate* **increases permanently** during the entire simulation.

1. Read Box 9.

Box 9. What is an exogenous influence.

If you want a quantity to decrease, remain stable or increase throughout the simulation, you must add an external influence (an exogenous influence) to the quantity.

2. Set as initial value:
   - Make quantity *Inflate* from Agent *Human* increase exogenous (see →).

3. Simulate the model and inspect the result. Do all quantities now continue to increase?

Give your answer here...

6. The balloon is going to snap…

Now we're going to look at the material of the balloon.

If you keep inflating, the pressure in the balloon increases and the volume also increases. The bigger the balloon gets, the thinner the balloon wall becomes, the sooner the balloon can snap. How a material behaves when it stretches can be seen in the (stress, strain) diagram (see Figure 2). Typical areas are:

- Area I: elastic deformation
- Area II: plastic deformation

After plastic deformation, the balloon will snap at some point.

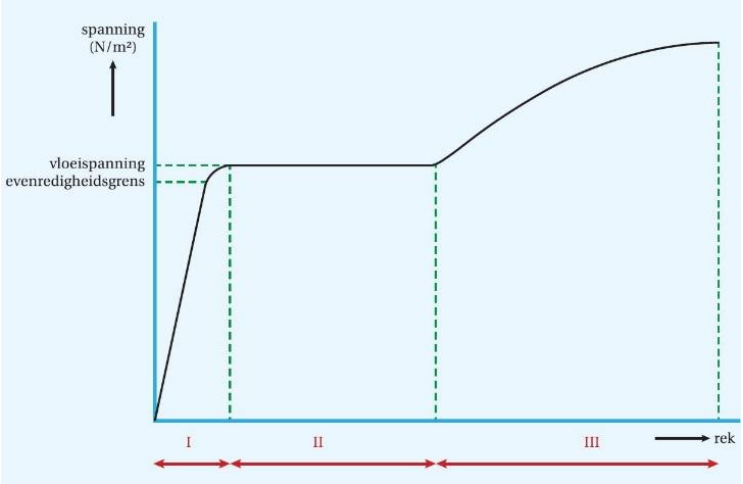


Figure 2. Deformation of the balloon material.

1. Give the **quantity** *Stretch* (of Balloon) a **quantity space** with five values, which represent the characteristic strain states: *rest length*, *elastic deformation*, *proportionality limit, plastic deformation,* and *snap*. Pay attention to the value type: is the value a **point** or an **interval**? (see →)

2. Set the **initial value** to the lowest value (*rest length*) of *Stretch*.

3. Run the simulation. Does **quantity** *Stretch* now reach its highest level (snap)?

    - The outcome of this simulation may not be what you expected. All kinds of states emerged. Click on them. Which states are incorrect? Give the numbers of at least 2 states that are incorrect and describe what is wrong.

Give your answer here...

4. Go to the last assignment for an explanation and completion of your model.

7. Correspondence

The outcome of assignment 6 is not yet satisfying. After all, the **quantities** *Volume* and *Stretch* are linked to each other, they correspond. If *Volume* increases, then *Stretch* increases proportionately. If *Volume* is set to max, then *Stretch* is set to snap.

In the model, we can indicate this by creating correspondences.

1. Read Box 10.

Box 10. Correspondence.

In a system, it can happen that certain values of different quantities can only occur together. You can then make a **correspondence** between the quantity spaces of those quantities.

2. Create in your model two **Correspondences** between *Volume* and *Stretch*, namely:
   - one between the **value** 0 (of *Volume*) and *rest length* (of *Stretch*), and
   - one between the **value** *max* (of *Volume*) and *snap* (of *Stretch*).

3. Set the initial value to the lowest **value** (0) of *Volume.*

4. Make *Inflate* increase continuously (as previously in assignment 5).

5. Simulate the model.
   - How many states are there now?
   - Do these align with your expectation?
   - Explain why.

Give your answer here...