



Star properties

This lesson is about properties of stars

DynaLearn level 2 | Version 1.0

Summary	
When you look at the sky at night, you can see that not all stars are identical. Some have a blue colour, others are a bit redder. In this lesson you will explore how and why stars differ from each other.	
Given name	
Surname	
Class	
Date	
Comments by teacher	



Introduction

When you look closely at the stars in the night sky, you can see that they aren't identical. Some stars appear brighter, others are so faint that they are only just visible. The colour of the stars also varies. Some stars appear to be bluer; others appear redder in colour. These differences are partly due to the distance between the stars and the Earth – some stars are closer to the Earth, others much further away - but mainly because there is a large variation in the appearance of the stars themselves. In this lesson you will build a model to discover why the stars are different.

You will build the model using the DynaLearn software. The model represents the most important components of a star, such as the core and the surface. Each component has a number of quantities which refer to measurable properties, such as mass, radius, temperature, etc. All entities and the associated properties (quantities) and units for the model are summarised in Table 1. The properties are described below.

Table 1. Star properties.

Entity	Quantity	Unit
Star	Mass	M_{Sun} (mass of the Sun; so for the Sun, mass = $1M_{\text{Sun}}$)
	Gravity	Newton
	Gas pressure	Pascal
	Lifespan	Years
	Radius	R_{Sun} (radius of the Sun)
Core	Pressure	Pascal
	Temperature	Kelvin
	Fusion-energy	J/s
Surface	Luminosity	L_{Sun} (luminosity of the Sun)
	Wavelength	Metre
	Temperature	Kelvin

Quantities referring to the properties of the **star** as a whole are the total **mass** and the **radius**. Another quantity is **gravity**, which holds the gas in the star together and 'pulls' it towards the centre of the star. The **gas pressure** quantity refers to the outward pressure, which opposes gravity. This creates balance in the system. Without the gas pressure, the star would collapse under the influence of its own gravity. The last quantity is **lifespan**. This indicates how long the star spends on the *main sequence*, a phase in which the star converts hydrogen into helium. You can think of the main sequence as a star's 'adult' stage of life: spends by far the majority of its lifespan here and changes very little during this phase. This is in contrast to the phase before, the formation, and the later phase, when the star begins to burn elements heavier than hydrogen, evolving and changing rapidly and eventually dying. *In this lesson we consider only stars on the main sequence.*

The **core** is the extremely hot and dense region in the centre of a star. The core is the 'engine' of the star, the part that generates energy through nuclear fusion. The quantity **fusion-energy** is a measure of the total amount of energy generated by the core per unit time through nuclear fusion. During the formation of the star, increasing mass causes increasing gravity. This increases the **pressure** and **temperature** in the core.



Once the temperature in the core is high enough, nuclear fusion begins and hydrogen fuses into helium. The fusion-energy in the core has a positive effect on the **gas pressure** in the star. At the same time, a higher fusion-energy shortens the **lifespan** of the star.

The **surface** is the outside or ‘appearance’ of the star. The energy generated in the core leaves the star via its surface in the form of radiation. The quantity **luminosity** indicates how much energy the star’s surface radiates into space in a certain direction per unit of time. The quantity **wavelength** refers to the wavelength at which most of the light is emitted. Finally, **temperature** is the temperature of the star’s surface. The radius of a star can be hundreds of thousands to millions of kilometres meaning the surface is far away from the core. As such, the surface temperature of a star will be a lot lower than that of the core.

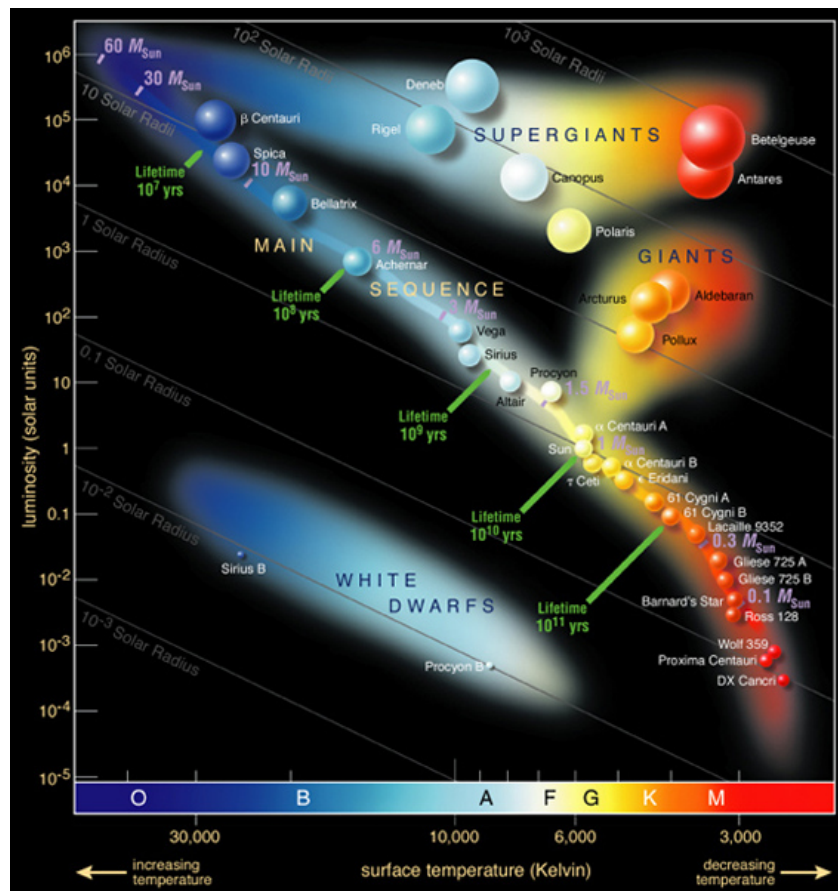


Figure 1. Types of stars on the Hertzsprung-Russel diagram.

Get started...

This tutorial leads you through the step-by-step process of making the model ‘Star properties’ in DynaLearn. All of the information you need to complete the lesson is included in the tutorial. Turn the page to get started.



1. Starting DynaLearn

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



Check!

After logging in, you will automatically enter in the white workspace of the assignment.

You can recognize it by the grey question mark on the right side of the screen . Is the question mark missing? Then first do the following:

- In DynaLearn, click . Next **click** on 'Select norm model'.
- **Choose** 'Star properties' and **press** 'Load'.

Save model file and start:

1. **Click** on  top left. Change the name to 'Star properties' and **click** 'Save'.
2. How to proceed? **Just follow** the steps in this tutorial. Note! You can't skip steps. Ask for help if you do not understand a certain step. The **boxes** contain brief explanations about model ingredients. The video function  in DynaLearn shows how model ingredients can be created. Put a check mark \checkmark next to the step you completed. This way you keep track of where you are in the assignment.




2. Entity stars with two quantities



You will first make a small model with the entity stars and the associated properties: mass and gravity. We call such properties ‘quantities’.

- a. **Read** Box 1 about the model parts.

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).

- b. **Create** an **entity** and give it the name ‘Stars’ (see  → ).

- c. **Read** Box 2.

Box 2. Help function



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





- d. The entity ‘Stars’ has several **quantities** (see Table 1). **Add** only the quantities ‘Mass’ and ‘Gravity’ to your model (see  → ).

- e. **Read** Box 3.

Box 3. Cause-and-effect relationships









In Dynlearn, 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)

- f. **Create** the **cause-and-effect** relationship ( or ) between these two created quantities. Note the direction of this relationship (see  → ).

- g. **Read** Box 4.

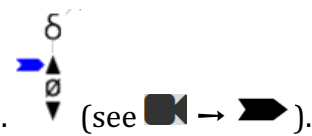
Box 4. Change of a quantity.

A quantity  can change. This is indicated by δ    . The delta symbol (δ) is the mathematical sign for change (also known as the derivative). The down arrow () is decrease, the zero () is constant and the up arrow () is increase.

- h. You are now going to **simulate** the model. For this you must define an **initial value**. A **quantity** in the model will increase or decrease.



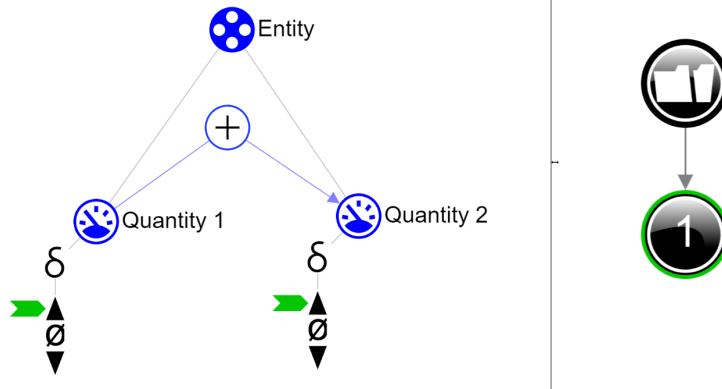
- i. Start with increasing 'Mass'. Click for entity 'Mass' on ▲ and choose ➡. On your screen you will see this symbol connected to 'Mass'.



- j. 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 state in this example ①.



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 because of that *Quantity 2* also increases.

- k. Read Box 6.

Box 6. Help function

If the exclamation mark appears !, something went wrong during the simulation. Click on the exclamation mark ! for a hint. Then click on a number, for example ①, to locate the error in your model.

- l. Simulate the model by clicking on ▶ and then clicking on ①.
- m. Vary the initial value for 'Mass' (set ➡ one by one on ∅ and on ▼) and simulate the model again by clicking on ▶.
- n. Write the results of your simulations in Table 2 below.

Table 2. Assuming you have a group of stars, compare the Mass and Gravity of the stars (select the correct answers).

If the Mass of the Stars...	... the Gravity ...
decreases	<i>decreases / remains the same / increases</i>
remains the same	<i>decreases / remains the same / increases</i>
increases	<i>decreases / remains the same / increases</i>



3. Properties of the core

Stars have an inside, the core, and an outside, the surface. The core is the active centre of the star where nuclear fusion takes place. You are now going to add properties of the core to your model.

- Create a new **entity** called 'Core' (see →).
- Click on the entity 'Stars' and select the **configuration** option to create a connection between the entities 'Stars' and 'Core' (see → →): *Stars have a Core.*
- Add three **quantities** to the entity 'Core': 'Pressure', 'Temperature' and 'Fusion-energy' (Table 1). (see →).
- Is your screen content a bit messy? Click to align everything neatly. Click to fit your model on your screen.
- What causes fusion-energy? Create the **cause-and-effect** relationship (or) between these new quantities to indicate this (see →). Note the direction of the connections. Also create a connection with one of the quantities of the entity 'Stars'.
- You are now going to **simulate** the model again. You must indicate an **initial value** (see →):
 - Start with increasing 'Mass'. Click for entity 'Mass' on and choose .
 - Simulate your model by clicking on and then on .
 - (Note: If an exclamation mark appears on your screen, read Box 6).
 - Vary the initial value for 'Mass' (set one by one on and on) and simulate the model again by clicking on .
 - Write the results of your simulations in Table 3 below.

Table 3. Assuming you have a group of stars, compare the Mass and the Pressure, Temperature and Fusion-energy in their cores (*select the correct answers*).

If the Mass...	... then the Pressure and the Temperature in the Core...	...and the Fusion-energy in the Core...
decreases	<i>decreases / remains the same / increases</i>	<i>decreases / remains the same / increases</i>
remains the same	<i>decreases / remains the same / increases</i>	<i>decreases / remains the same / increases</i>
increases	<i>decreases / remains the same / increases</i>	<i>decreases / remains the same / increases</i>



4. Properties of the surface

You are now going to add surface properties to your model.




- Create** a new **entity** called 'Surface'.
- Click** on the entity 'Stars' and **select** the **configuration** option to create a connection between the entities 'Stars' and 'Surface': *Stars have a Surface*.
- Surface has three **quantities** (Table 1). **Add** these quantities to 'Surface'.
- Create** the **cause-and-effect** relationships (\oplus of \ominus) between these quantities. Also **create** one relationship with the previously added quantities. *Tip: pay attention to the properties of the Core...*
- You are now going to **simulate** the model again. You must indicate an **initial value**.
 - Start with increasing 'Mass'. **Click** for entity 'Mass' on \blacktriangle and choose \blacktriangleright .
 - Simulate** your model by clicking on  and then on .
 - (*Note: If an exclamation mark appears on your screen, read Source 3*).
 - Vary** the initial value for 'Mass' (set \blacktriangleright one by one on \emptyset en \blacktriangledown) and simulate the model again by clicking on .
 - Write** the results of your simulations in Table 4 below.

Table 4. Assuming you have a group of stars, compare the Mass, Wavelength and Luminosity of the stars (*select the correct answers*).

If the Mass...	... then the Wavelength...	...and the Luminosity...
decreases	<i>decreases / remains the same / increases</i>	<i>decreases / remains the same / increases</i>
remains the same	<i>decreases / remains the same / increases</i>	<i>decreases / remains the same / increases</i>
increases	<i>decreases / remains the same / increases</i>	<i>decreases / remains the same / increases</i>



5. What else do we know?

There are three properties (quantities) in Table 1 that are not yet included in the model. It's up to you to find them and add them to your model!

- a. **Read** Box 7 to determine if your model is complete.

Box 7. Progress bar

At the bottom of the screen is the *progress bar* (see example below).

Entity shows: 4/4/0, this means: 4 created, 4 needed, 0 error. For quantity it shows : 5/17/1: this means: 5 made, 17 needed, 1 error. If all the numbers are green, that ingredient type is completed.



- b. **Find** the three missing **quantities** (Table 1) and **add** them to your model. Use the help function (Box 2) and the progress bar (Box 7).
- c. *Three* cause-and-effect relationships are needed to connect the new quantities to the rest of the model. **Create** these **cause-and-effect** relationships.
- d. You are now going to **simulate** your model.
 - o **Start** with increasing 'Mass'.
 - o **Simulate** the model and then **vary** the initial values for 'Mass'.
 - o **Write** your results in Table 5.

Table 5. Assuming you have a group of stars, compare the Star properties: **If Mass ...**, **then ...** (select the correct answers).

Mass	Radius	Fusion-energy	Lifespan	Wavelength	Luminosity
▲	▲ / ∅ / ▼	▲ / ∅ / ▼	▲ / ∅ / ▼	▲ / ∅ / ▼	▲ / ∅ / ▼
∅	▲ / ∅ / ▼	▲ / ∅ / ▼	▲ / ∅ / ▼	▲ / ∅ / ▼	▲ / ∅ / ▼
▼	▲ / ∅ / ▼	▲ / ∅ / ▼	▲ / ∅ / ▼	▲ / ∅ / ▼	▲ / ∅ / ▼