

Force

3 HV TTO Physics

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September, Oktober



General Information

Contact BXM

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Structure

- Website: www.becxlibrary.nl
- Website info: This contains all the files you need for my lessons. **Is something missing or is there a mistake? Please let me know as soon as possible through one of the contact options. Thanks in advance!**

Don't forget!

The universe is not obligated to make sense to you! So always ask questions!

Important Information

Materials List

- Pen (Writing)
- Pencil (Drawing)
- Set square (*Optional extra ruler*)
- Basic calculator (*Non-graphical and/or programmable*)
- Book; Science School Chapter 3, Force

Tips

- Use these slides for structure!
- You are always allowed to write and mark on the test. It will be handed in but not taken into account in the grading!
- Always work carefully and in a structured way.
- You can always ask me for help! So please do :)



Figure: Newton under a tree



Figure: Golden Gate Bridge

Section 1; Types of Forces

Point of Application

This is the location where a force acts on or pulls the object. A force is represented by a **vector**, which is not always drawn to scale. A vector is drawn from the point of application, with a straight line and an arrow at the end. It is denoted by F with a subscript indicating the type of force.

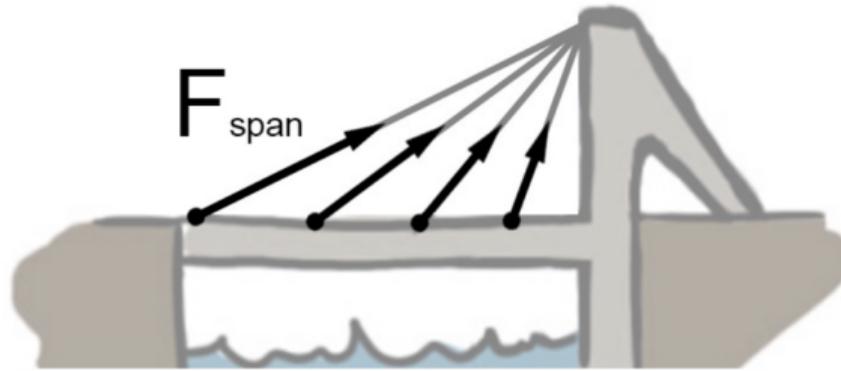


Figure: Points of application on a bridge

Section 1; Gravitational Force

Gravitational Force

The **force** required to accelerate an object with a certain **mass** using the **gravitational acceleration** that applies at that moment.

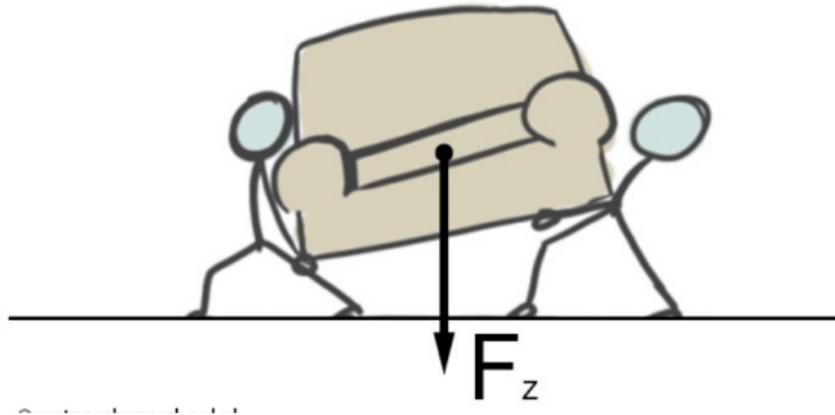


Figure: Gravitational force acting on the mass point of the object

Section 1; Learning goals

Today

- I understand what a vector is and how to use it
- I understand the difference between mass and weight
- I can draw and calculate the gravitational force
- I can draw and calculate the spring force



Section 1; Gravitational Force

Formula

The formula for gravitational force:

$$F_g = m * g \quad (1)$$

Where

- F_g is the gravitational force in $[N]$
- m is the mass in $[kg]$
- g is the gravitational acceleration in $[m/s^2]$
- Assume Earth's gravitational acceleration unless otherwise stated

Note!

The *mass* of an object **NEVER** changes, but the *weight* **CAN** change.

Section 1; Gravitational Force

naam	symbol	type	ontdekkng	baanstraal	omloopafst	hellng t.o.v. ecliptica	straal (equator)	massa	dichtheid	gravitatieversnelling aan het oppervlak	omdraaiingsomheuld	sidertische rotatieperiode	gemiddelde oppervlakte-temperatuur	gassen in de atmosfeer	aantal satellieten (naamen en ringen)
				m	d, y	°	10 ⁶ m	10 ²⁴ kg	kg m ⁻³	m s ⁻²	10 ³ m s ⁻¹ d	K			
Mercurius	♿	planeet	oudheid	0,0579 · 10 ¹²	87,97 d	7,0	2,440	0,330	5430	3,7	4,2	58,65	440	He, H ₂	0
Venus	♀	planeet	oudheid	0,1082 · 10 ¹²	224,7 d	3,4	6,052	4,87	5240	8,87	10,4	-243 ¹	737	CO ₂ , N ₂	0
Aarde	♁	planeet	oudheid	0,1496 · 10 ¹²	365,256 d	0,0	6,371 ¹	5,972	5513	9,81	11,2	0,9973	288	N ₂ , O ₂ , Ar	1
Maan	☾	maan	oudheid	384,4 · 10 ⁶	27,32 d	5,2 ¹	1,738	0,0735	3340	1,62	2,38	27,32	253	He, H ₂	-
Mars	♂	planeet	oudheid	0,228 · 10 ¹²	687,0 d	1,8	3,390	0,642	3930	3,7	5,0	1,026	208	CO ₂ , N ₂ , Ar	2
Phobos		maan	1877	9,37 · 10 ⁶	0,319 d	1,1 ¹	0,011 ¹	1,07 · 10 ⁻⁸	1900	0,0057	0,04	0,319	-	-	-
Deimos		maan	1877	23,5 · 10 ⁶	1,262 d	1,8 ¹	0,006 ¹	1,5 · 10 ⁻⁷	1470	0,003	0,07	1,26	-	-	-
Ceres	♁	dwerfplaneet	1801	0,414 · 10 ¹²	4,600 y	10,6	0,476	9,5 · 10 ⁻⁴	2090	0,28	6,7	0,38	168	-	-
Jupiter	♃	planeet	oudheid	0,7883 · 10 ¹²	11,86 y	1,3	69,91	1900	1330	24,9	60	0,413	163	H ₂ , He, CH ₄ , NH ₃	79+r
Io		maan	1610	421,8 · 10 ⁶	1,769 d	0,004 ¹	1,822	0,089	3530	1,8	2,38	1,77	118	SO ₂	-
Europa		maan	1610	670,9 · 10 ⁶	3,551 d	0,01 ¹	1,568	0,048	3010	1,32	7,29	3,55	103	O ₂	-
Ganymedes		maan	1610	1070 · 10 ⁶	7,155 d	0,18 ¹	2,631	0,148	1940	1,43	9,87	7,18	113	O ₂	-
Callisto		maan	1610	1883 · 10 ⁶	16,689 d	0,19 ¹	2,410	0,1076	1830	1,24	8,79	16,69	118	CO ₂	-
Saturnus	♄	planeet	oudheid	1,427 · 10 ¹²	29,45 y	2,5	58,2	568	687	11,2	36,1	0,444	133	H ₂ , He, CH ₄ , NH ₃	82+r
Uranus	♅	planeet	1781	2,871 · 10 ¹²	84,02 y	0,8	25,4	86,8	1270	8,9	21,4	-0,718 ¹	76	H ₂ , He, CH ₄	27+r
Neptunus	♆	planeet	1846	4,498 · 10 ¹²	164,8 y	1,8	24,6	102,4	1640	11,2	23,6	0,671	73	H ₂ , He, CH ₄	14+r
Pluto	♇	dwerfplaneet	1930	5,91 · 10 ¹²	247,9 y	17,1	1,15	0,0131	2050	0,66	1,23	6,39	48	N ₂ , CH ₄ , NH ₃	5
Charon		plutino	1978	0,0196 · 10 ¹²	6,4 d	0,001 ¹	0,63	0,0016	1650	0,28	0,58	synchroon	45	-	-
Haumea		dwerfplaneet	2003	6,43 · 10 ¹²	239,1 y	28	1,4	0,0042	3000	0,44	0,84	0,16	<50	-	2
Quaoar		TNO ¹	2002	6,5 · 10 ¹²	283 y	8	0,65	0,002	2000	0,3	0,5	0,74	43	CH ₄	-
Makemake		dwerfplaneet	2003	6,78 · 10 ¹²	296,1 y	29	0,73	0,004	2000	0,4	0,75	0,17	33	CH ₄	1
Eris		dwerfplaneet	2003	10,2 · 10 ¹²	557 y	47	1,4	0,0167	2500	0,83	1,4	1,08	33	CH ₄	1
Sedna		centaur	2003	72 · 10 ¹²	11400 y	11,9	0,75	0,004	2000	0,4	0,8	0,43	33	N ₂ , CH ₄	-

1 ▶ 8 planeten, 5 dwergplaneten, 2,6 · 10⁷ planetoïden (kometen, centaurs, TNO = Trans Neptunus Object)

2 ▶ Bij de manen is de hellng van het baanvlak t.o.v. de planeetbaan (dus niet t.o.v. de ecliptica).

3 ▶ pool: 6356,7523142 km; evenaar: 6378,1370 km

4 ▶ onregelmatig van vorm

5 ▶ De rotatierichting is tegengesteld aan de draaiing in de baan.



Section 1; Types of Forces

List of Forces

- Gravitational force F_g
- Normal force F_n
- Spring force F_s
- Resultant force F_{res}
- Frictional force F_w
- Tension force F_t
- Motor force F_m
- Magnetic force F_{mag}
- Lorentz force F_l

Note!

These are examples, make sure you know which ones you need to understand!

Section 1; Spring Force

Spring Force

The spring force indicates how much force is needed to stretch a spring of a certain material by a certain distance. **Note!** This also applies to compressing a spring, but in the opposite direction.

$$F_s = C * u \quad (2)$$

Where

- F_s is the spring force in $[N]$
- C is the spring constant in $[N/m]$ (*Indicates how stiff/strong a spring is*)
- u is the elongation in $[m]$



Section 1; Spring Force

Spring Force

See the figure below for the visualization of the formula. **Note!** The gravitational force is also not drawn correctly here; it should be drawn from the center of mass.

$$F_s = C * u \quad (3)$$

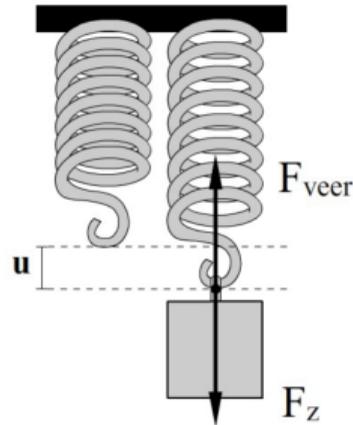


Figure: The spring force

Section 2; Resultant Force

Lessen goals

- I can work with a force scale
- I can calculate the resultant force
- I understand the effect of a resultant force



Section 2; Resultant Force

Force Scale

The scale that determines how large a force is in a drawing. When a vector is drawn, the magnitude of the force can be expressed using the scale.

$$1 \text{ cm} \triangleq 10 \text{ N} \quad (4)$$

So:

In this example, *each centimeter* in the drawing represents *10 Newton*.



Section 2; Resultant Force

Using the Force Scale

By using a force scale or by drawing a larger vector compared to another, the relative magnitudes of the forces become clear. Forces can also be equal in size, which is shown when the vectors are the same length.

Resultant Force

The **resultant force** is the total sum of all forces acting on an object. This force is drawn like a real force, but it does not exist on its own. It is only used to calculate what will happen to the object.



Start

- Recap resultant force (general)

Learning goals

- I understand the effect of a resultant force
- I can calculate the resultant force when 2 forces do not have the same value

Section 2; Resultant Force

Same Direction

When forces act in the same direction, they can be **added** together. There must be no angular difference between them. *Parallel forces are allowed!*

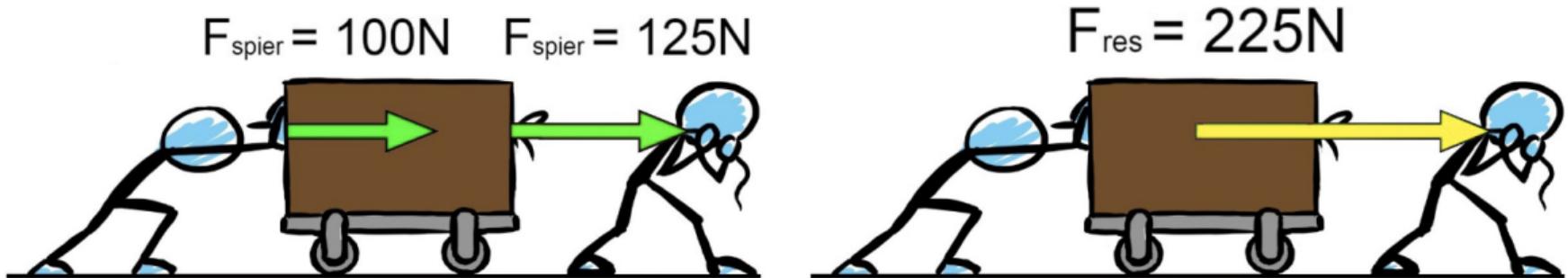


Figure: Forces in the same direction

Section 2; Resultant Force

Opposite Direction

When forces act in opposite directions, they can be subtracted from each other. There must be no angular difference between them. *Parallel forces are allowed!*

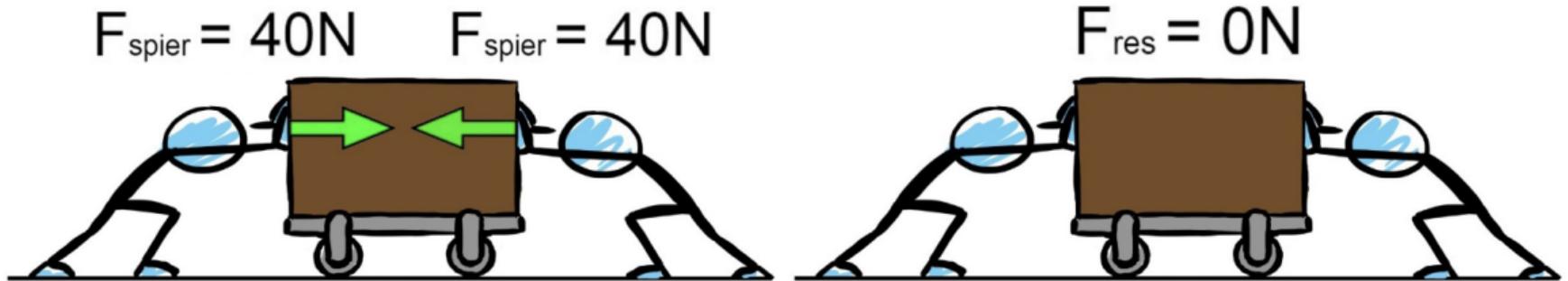


Figure: Forces in opposite direction

Section 2; Resultant Force

Another Example of Opposing Forces

Another example is when the forces don't cancel out to 0 N . The same rules apply! In this case, the person on the left will win. **Note!** The force itself hasn't changed, but now the resultant force is used to make the calculation.

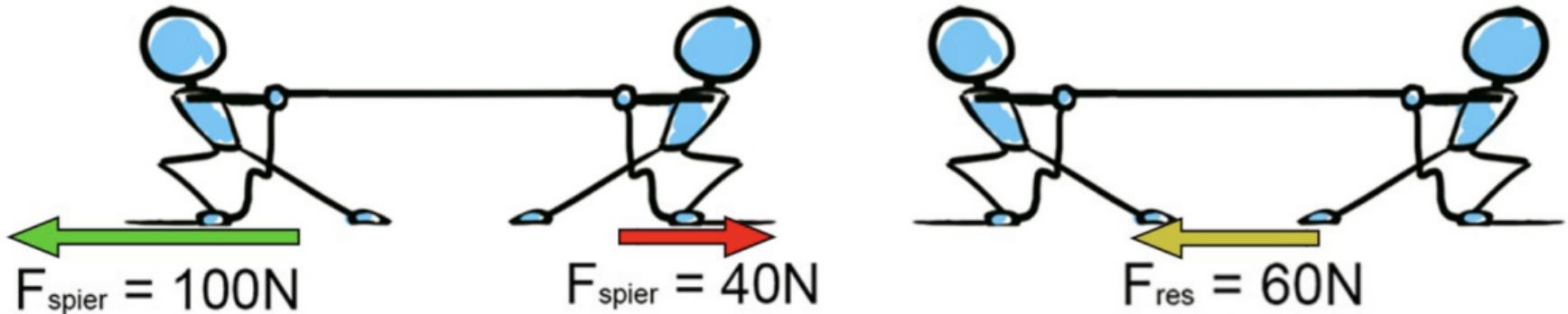


Figure: Another example of forces in opposite directions

Section 2; Parallelogram Method

Using the Parallelogram Method

The resultant force can also be calculated when forces are not parallel to each other, and there is an angular difference. The **parallelogram method** was developed for this. **Note!** The vectors must be drawn to scale to be correct.

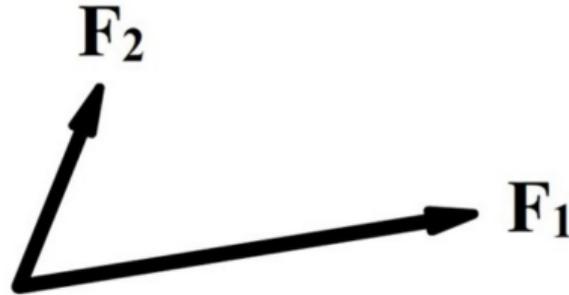


Figure: Parallelogram method

Section 2: The Parallelogram Method

Start

Once the "abstract" drawings have been made, the parallelogram method can be applied. See the figure below.

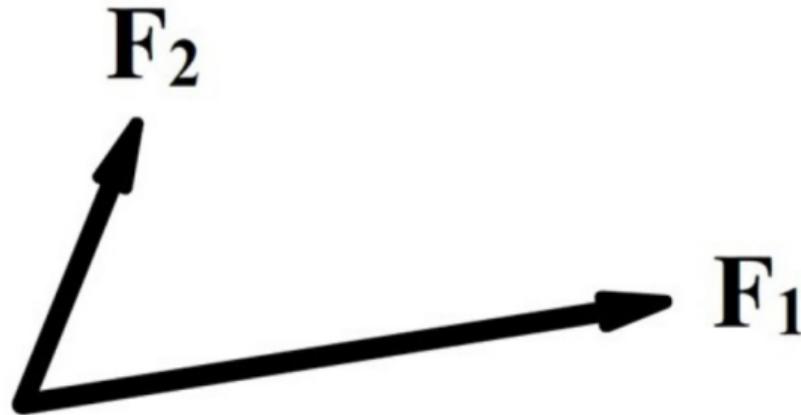


Figure: Initial drawing for the parallelogram method

Section 2: The Parallelogram Method

How to Draw Parallel Lines?

Next, parallel dotted lines are drawn relative to the original forces. See the figure below.

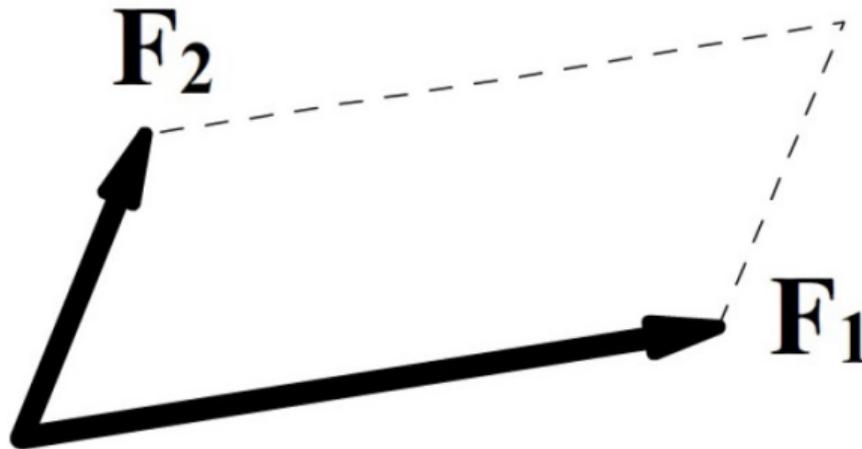


Figure: The drawn parallel lines

Section 2: The Parallelogram Method

Drawing the Resultant Force

The parallel lines intersect, and that is the point of intersection. From the point where the two forces apply to the intersection, the resultant force (F_{res}) is drawn. See the figure below.

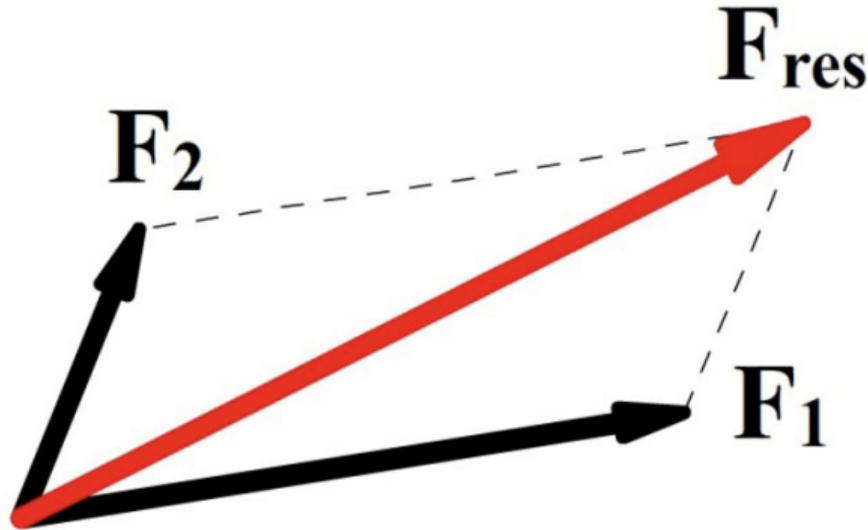


Figure: The drawn resultant force

Section 2: The Parallelogram Method

Determining the Magnitude of the Forces

Once the resultant force has been drawn, the magnitude of the force can be determined using the force scale. Create a scale or check where it is given. Measure the force and multiply it by the scale. The result is the magnitude of the force. See the figure below.

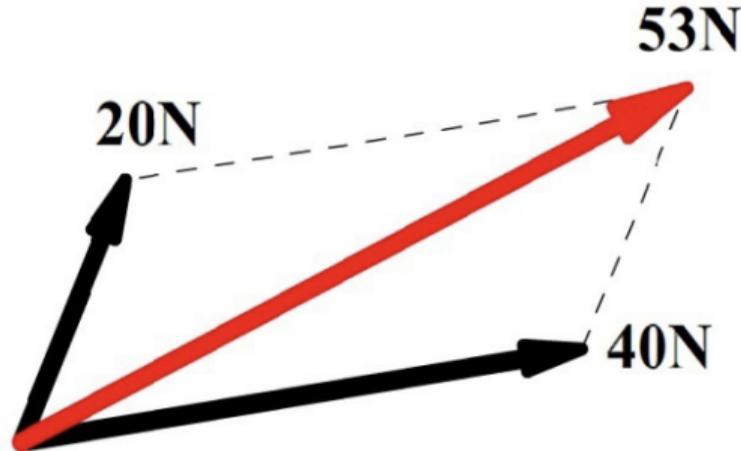


Figure: The drawn resultant force with magnitude

Section 2: The Parallelogram Method

The Steps of the Parallelogram Method

- 1 Find and note the force scale. If it is not indicated, proceed to step 2.
- 2 Measure the known forces and create a force scale, using the data already available.
- 3 Draw parallel dotted lines relative to the original forces.
- 4 Draw the resultant force from the point of application to the intersection of the parallel dotted lines.
- 5 Calculate the magnitude of the resultant force.
- 6 **Be aware that the question may ask you to perform everything in reverse or that some data is already known.**



Section 2: The Parallelogram Method

The Pythagorean Theorem

When there is a 45° angle between the forces, the Pythagorean theorem can be used. In the figure below, it can also be seen that the parallelogram method works in this case.

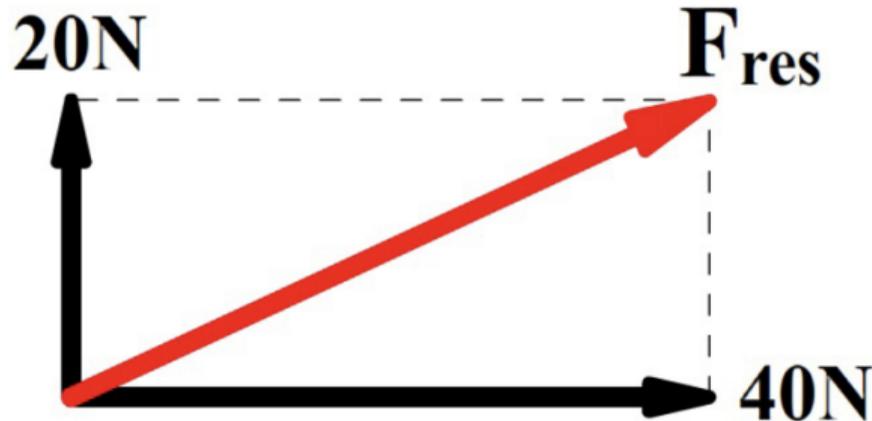


Figure: Calculating the resultant force using the Pythagorean theorem

Section 2: The Parallelogram Method

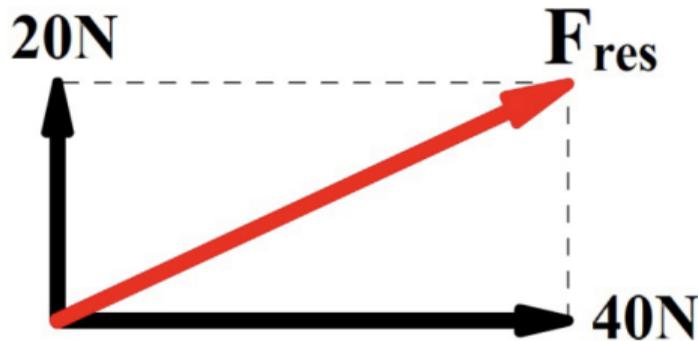


Figure: Calculating the resultant force using the Pythagorean theorem

$$a^2 + b^2 = c^2 \quad (5)$$

$$c = \sqrt{a^2 + b^2} \quad (6)$$

$$c = \sqrt{20^2 + 40^2} = 45 \text{ N} \quad (7)$$



Section 2; Resultant force

Definition resultant force

The resultant force is the total sum of all forces acting on an object. This force is drawn like a real force, but it does not exist on its own. It is only used to calculate what will happen to the object.

$$F_{res} = m * a \quad (8)$$

Where

F_{res} is de resultant force in [N]



Section 3: Force Equilibrium

Definition

Force equilibrium means that forces are equal to each other. When forces are of equal magnitude and act in opposite directions, they are in equilibrium. For example, gravity and the normal force. The normal force prevents the object from going through the ground.

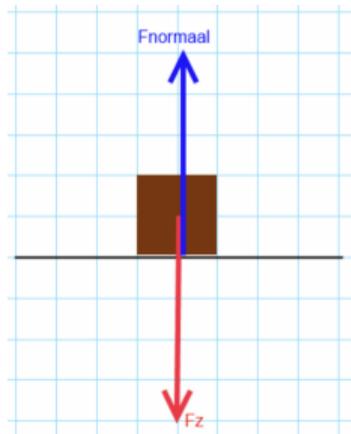


Figure: The equilibrium of gravity (F_z) and the normal force (F_n)

Section 3: Force Equilibrium

Force Equilibrium in a Drawing

In a force equilibrium, the parallelogram method can be used to calculate the opposing force. **The gravity is not drawn correctly here! It should be drawn from the center of mass of the block.**

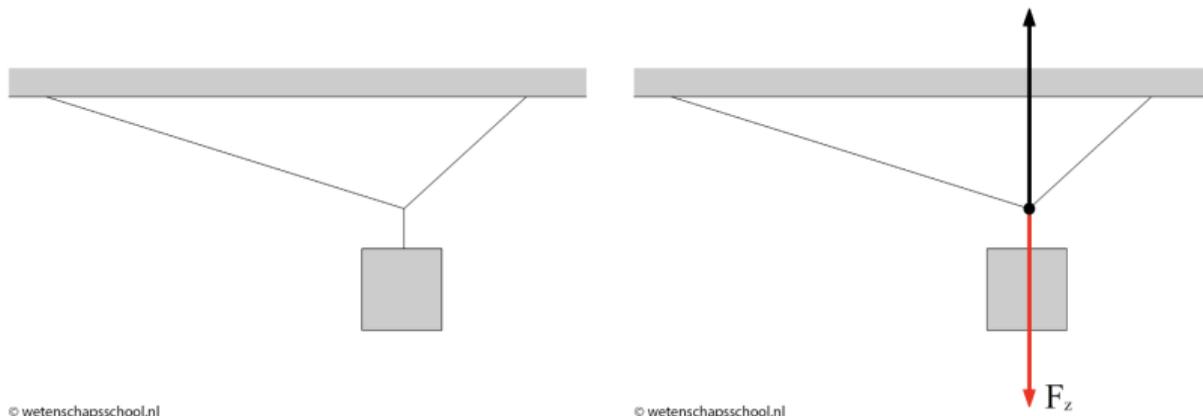


Figure: The initial drawings of force equilibrium using the parallelogram method

Section 3: Force Equilibrium

Force Equilibrium in a Drawing

Next, the rest of the steps of the parallelogram method can be carried out. **The gravity is not drawn correctly here! It should be drawn from the center of mass of the block.**

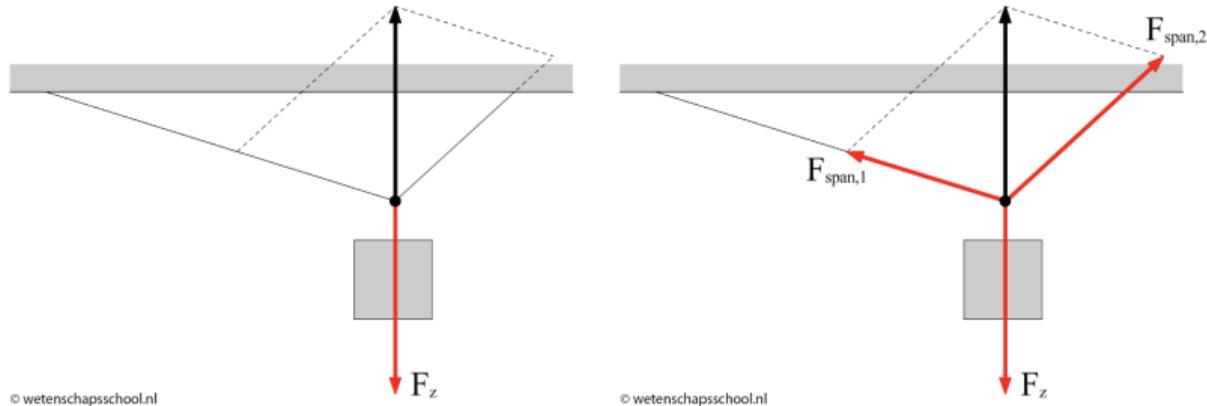


Figure: The subsequent drawings of force equilibrium using the parallelogram method

Section 4: Newton's First Law

Definition

When all forces acting on an object are in equilibrium, the resultant force is 0 N . The object therefore remains stationary or moves with a constant velocity.

The Use of Newton's First Law

Newton's first law allows us to determine how forces should act to change the motion of an object. See the next slide!



Section 4: Newton's First Law

Acceleration

When an object must accelerate from rest, there must be a 'resultant' force (to the right) that is greater than the resistance force (to the left).



Figure: The forces during acceleration

Section 4: Newton's First Law

Constant Motion

When an object is stationary or moves at constant speed, all forces are in equilibrium and therefore equal. This follows from Newton's first law.



Figure: The forces during constant motion

Section 4: Newton's First Law

Deceleration

When an object slows down, there must be a force that creates greater resistance.



Figure: The forces during deceleration

Paragraph 4; Newton's First Law

In the Air

This is how the gravitational force (F_z) and the drag force (F_w) look for a ball in the air.

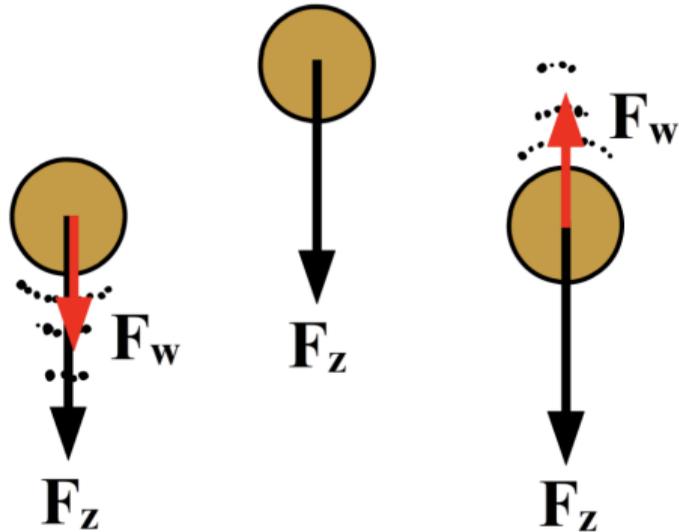


Figure: Forces on the ball in the air

Paragraph 5; Resolving Forces

Resolving

When resolving forces, a single force is split into two components. The reverse parallelogram method is used in the following example.

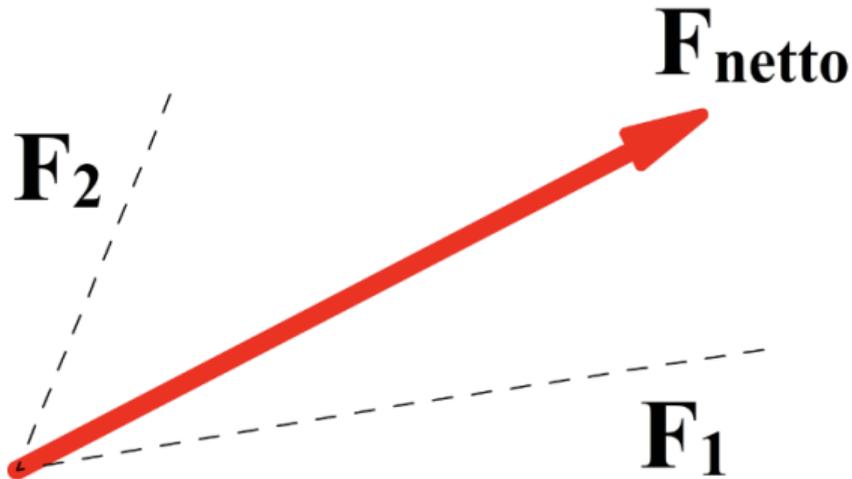


Figure: $F_{netto} = F_{res}$

Paragraph 5; Resolving Forces

Reverse

Then, the same steps can be taken as in the parallelogram method, but in reverse.

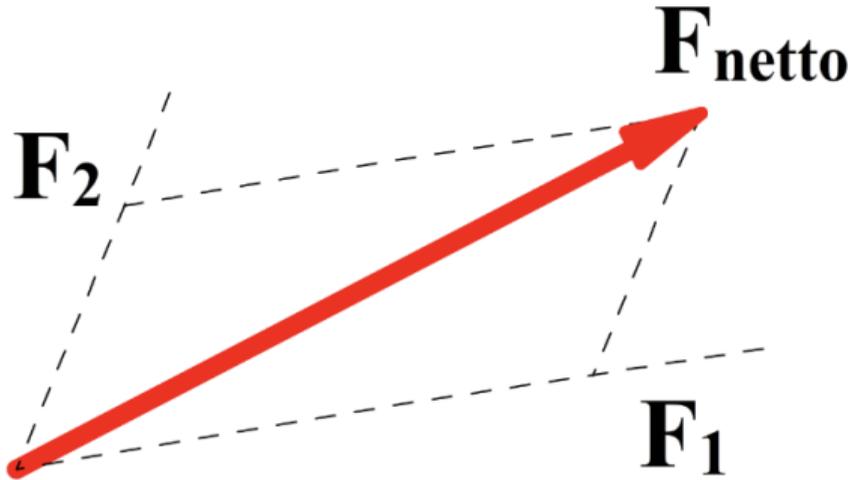


Figure: $F_{netto} = F_{res}$

Paragraph 5; Resolving Forces

Final Step

Next, the original forces of the resulting (net) force are drawn.

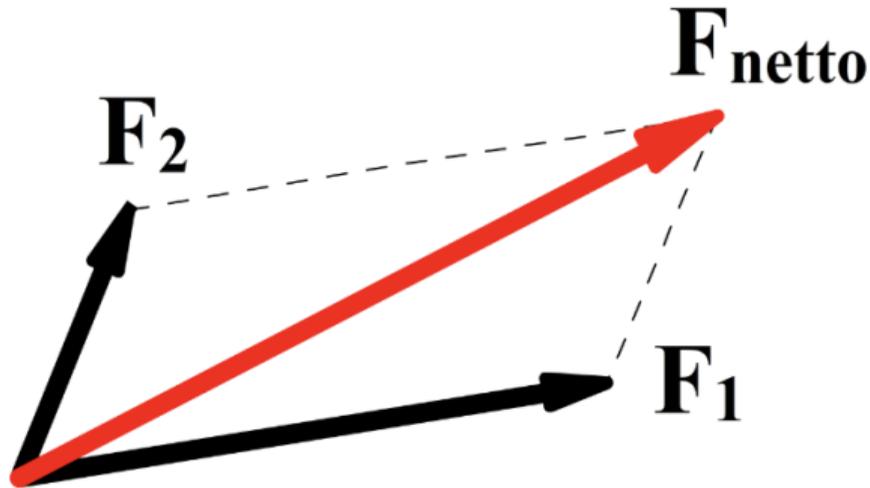


Figure: $F_{netto} = F_{res}$

Chapter Conclusion; Force

Topics; Force		
KB1: Types of Forces	KB2: Drawing Forces	KB3: Resultant Force
<ul style="list-style-type: none">● Identifying different types of forces● Gravitational force● $F_z = m * g$● Spring force● $F_{spring} = C * u$	<ul style="list-style-type: none">● Drawing forces to scale● Parallelogram method● Composing and resolving forces	<ul style="list-style-type: none">● Newton's First Law● Newton's Second Law● $F_{res} = m * a$



Chapter Conclusion; Force

Skills; Force			
V1: Mathematical Skills	V2: Systematic Problem Solving	V3: Practical Skills (Experiments)	V4: Model Development
<ul style="list-style-type: none">● Converting units (speed, time)● Calculating with scale● Calculating with formulas● Reading and drawing graphs	<ul style="list-style-type: none">● Given, asked, formula, elaboration● Extracting data from graphs● Extracting data from force diagrams	<ul style="list-style-type: none">● Force and motion● Hooke's Law● Mass and ruler	<ul style="list-style-type: none">● Drawing forces



Assessment; Force	
T1: Force and Motion	T2: Moment Experiment
● Summative	● Summative