ARPHYMEDES

TEACHER'S BOOK

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Cantarella Marco, Ursino Giuseppe Fabio,	Viteco (Italy)	Preparation of the graphic parts of the book, preparation of the cover, layout of textual and graphic content, adaptation of book to printing requirements and translations into partnership languages

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Pavlendová Gabriela, Varečková Ľubica, Marček Chorvátová Alžbeta	University of Ss. Cyril and Methodius (Slovakia)	Physics overview and coordination, check of English language, translation to Slovak.

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Introduction

The book for teachers is a supportive material to the interactive textbook on the ARphymedes Plus open web portal (https://studentbook.arphymedes-plus.eu/). The interactive textbook is designed for students with special educational needs and is the adapted multimedia version of the standard textbook, developed within the ARphymedes Project. The Teacher's book will help teachers to make sense of the materials for students on the online platform, place them in a contextual framework with additional verbal instructions and explanations, as well as the gathered information will also help the parents to understand the special needs of their children and help them to use the educational tool.

The multimedia student book on the online platform supports personalised learning and is tailored to the unique needs of all learners with different abilities and learning styles. To meet the specific needs of students that prevents from their nonparticipating in learning, and the online Student´s Book presents personalised learning content supported by multimedia presentations developed in ARphymedes project with ICT support to ensure accessibility, and the implementation of multisensory approaches to provide visual, tactile, and auditory support for the content presented. The book includes information on the inclusion of students with different disabilities in physics instruction and information, on the use of the online student book (how can students adapt the website accessibility to their specific needs, explanations to the content and guidance to the activities implementation, which include augmented reality). Students with disabilities thus could participate equally in the learning, with the possibility to adapt their learning process, and to learn with their own preferences and adapted settings.
The material collected and presented in the Teacher's Book provides teachers with strategies to respond to the special needs of students in an inclusive environment, provide guidelines on organising lessons, and give ideas on personalized teaching.
Nowadays, technology-and-computer-mediated learning has been increasingly at the forefront, where the content and materials open new concepts of educational work through the introduction of diverse e-materials and i-textbooks (Pesek et al., 2014).
The concept is based on experiential learning, rooted in the student recognition as a holistic being, and the nature as an indivisible whole. All of that also allows distance learning and offers an accessible source of explanation and exploration, where the student must be actively involved in cognitive processes, AR (augmented reality) and practical experiments. The students compare results with his classmates, online materials, complete and correct them, thus this way of teaching allows creativity, contributes more to the long-term memory, student´s independence, individualisation and differentiation of teaching, critical thinking and, moreover the skills development.

The term e-textbooks, as a broader category, covers three levels or types of e-textbooks related to the level of multimedia elements, the use of instant feedback questions, interactive tasks, and examples:

- *d-textbooks* or digitised textbooks are electronic copies of traditional printed textbooks, what means that they contain only text and images.
- *r-textbooks* are rich e-textbooks, where the d-textbook is the basis, with the addition of audio and video.
- *i-textbooks* (interactive e-textbooks) are characterised by the direct integration of interactive examples, constructions and tasks into the text of the i-textbook. The quality of the feedback is being improved, the answers can be saved, and the user can be monitored.

The great advantage of e-textbooks over traditional textbooks is the possibility to monitor the e-textbook use, to comment on it in a micro level (tasks, examples, descriptions), analyse and make corrections and changes. Therefore, it is faster and more efficient to create the improved e-textbook version, which can be refreshed easily by all users (Pesek et al., 2014).
The i-textbook must follow minimum content, didactic, technical-organisational and design requirements, such as (Pesek et al., 2014, pp. 33-34; Kopajnik, 2020):

- Professional relevance and correctness.
- Methodological and didactical relevance (general and subject-specific).
- Alignment with learning objectives, standards, or knowledge outcomes of the curriculum.
- Feedback (ongoing and final) with suggestions of further work in the case of learning content misunderstanding.
- Considering the developmental level of the student.
- Considering the students' abilities and learning potential.
- Respect for the general didactic principles (progression, demonstration, student activity, etc.), in particular the principle of multisensory learning, with didactically appropriate multimedia elements inclusion.
- The possibility of adapting to students with special needs.
- Considering the cultural background of students.
- Uniform external design and user experience.
- Linguistic appropriateness (emphasis also on the semantic or age-appropriate communicative value of the information, comprehensible explanatory texts, clear structures).

Accessibility of online materials for students with SEN

Society is becoming increasingly dependent on technologies for communication and access to information reasons, where people with special educational needs are experiencing an ever-increasing digital divide and stress, but everyone deserves to be exposed to general, as well as specialised, easy-to-use resources that enables them to carry out everyday tasks with greater ease and efficiency (Green, 2018). Digital products, such as interactive student books, should be accessible at the physical level as well as at the sensory and mental levels in line with the WCAG guidelines, and digital products should be designed as more accessible for people with special educational needs (SEN) (Debevc, 2021). The WCAG guidelines are based on four main areas: perceivable, operable, understandable, robust (W3C Web Accessibility Initiative (WAI), 2018). The key guidelines of each area are presented below.

Perceivable area

The needs of students with SEN according to perceptibility are presented in the Table 1 below.

Table 1. *The needs of individuals with SEN according to perceptibility (Debevc, 2021)*

Students with specific learning difficulties
• Simplified, clear and concise texts, images and/or videos. • Consistently the same sequential flow for tasks completion. • The provision of alternative interactive and presentation options (audio, image or tactile stimuli). • Support for non-visual perception (audio, tactile). • Audio output (together with speech). • Descriptions of sound. • Automatic computerised correction. • Computer-assisted speech. • Control of sound (stops, volume). • Speech output for non-text, image, and video media. • Speech language detection. • Non-visual error identification. • Audio for proof of payment. • Biometric methods for activity implementation. • Preservation of accessible information during implementation. • Tactile or acoustic status of the system. • Visual status of the system. • Display of the possibility to repeat an input.

- Display of double-typing option.
- Display of the caller's number.
- Subtitle playback and setting displaying subtitles (including live).
- Spoken subtitles.
- Synchronisation, playback, and storage audio.
- Contrast – changing.
- Colours – defining the colour scheme.
- Text shifts.
- Automatic offer of obstacle-free routes (navigation on the route, in the app).

Blind students / visually impaired students

- Support for non-visual perception (auditory, tactile).
- Audio output (together with speech).
- Sound descriptions.
- Automatic computer-aided correction speech.
- Control of sound (pause, volume).
- Speech output for non-text, image, and video media.
- Speech language detection.
- Non-visual identification of errors.
- Audio for proof of payment.
- Text and character magnification.
- Non-textual contrast.
- Text lags.
- Performing activities without a keyboard.
- Biometric methods for performing activities.
- Tactile or audio status display.
- Display of a functioning part of the product in different modalities.
- Display of the caller´s ID.
- Alternatives to video-based services.
- Subtitles – defining features and adjustments.
- Spoken subtitles.
- Synchronisation, playback, and storage audio.
- Contrasts – modifying.
- Colours – defining the colour scheme.
- Automatic offer of obstacle-free routes (navigation on the route, in the app).

Deaf students and students with hard of hearing
• Subtitle playback and setting their display (including live). • Playing video and adjusting its video display. • Audio playback and volume adjustment audio. • Private audio volume adjustment (without disturbing other people). • Resetting the sound volume. • Visual output for audio information. • Perform activities without a keypad. • Access to system functions without speaking. • Biometric methods to perform activities. • Preservation of accessible information during execution. • Visual display of system status. • Alternative display of non-text content.

Students with motor disability / Students with reduced mobility
• Performing activities without a keyboard. • Speechless access. • Biometric methods to perform activities. • Visual status of the current activity. • Standard connections to the network - permanent and stable. • Display of the possibility to repeat an entry. • Display of double-entry options. • Orientation in the application must be clearly visible. • Necessary information in audio and text mode. • Accessible documentation. • Offer templates for minimum complementarity in different applications. • Automatic offer of obstacle-free routes (navigation on route, in-app).

Debevc, M. (2021). Dostopnost digitalnih produktov za vse. [Digital products accessible to all.] University of Maribor – University Press.

Operable area

Operability refers to the way in which the user can operate the system (navigation in the user interface) (Debevc, 2021). It is recommended (W3C Web Accessibility Initiative (WAI), 2018):

- That all functionality is available from a keyboard.
- To give users enough time to read and use content.
- Not to use content that causes seizures or physical reactions.
- To help users navigate and find content.
- To make it easier to use inputs other than keyboard.

The needs of individuals with SEN according to operability are presented in the Table 2 below.

Table 2. *The needs of individuals with SEN according to operability (Debevc, 2021)*

Students with specific learning difficulties
• Controls in the visual environment (at eye level). • A control with a clear purpose and role. • A control with a specific, appropriately strong actuation pressure (gently, harder). • Flexible time to complete tasks. • Suitably adapted keyboard with no hidden keys. • Time setting for entering individual characters. • Allowing to pause and stop activities. • Possibility to return to the start position at any time. • Focus guidance on operation (display active elements). • The possibility to execute in multiple paths or multiple procedures. • Appropriately clear addressing of texts, and activities. • Activation through gestures and body movements. • The possibility to adjust the cursor (by moving, interruptions). • Possibility to adapt the presentation information (urgent and non-urgent). • Elimination of flickering visual effects on the display. • Reduction of the visual angle of the area repetitive patterns and speeds repetition. • Reduction of other light-sensitive triggers. • Alarm keys.

Blind students / visually impaired students
• A properly adapted keyboard with no hidden keys. • Setting the time for entering individual characters. • Enabling pause and stop activities. • The possibility to return to the start position at any time. • Focus guidance for operation (display of active items). • The possibility to follow several possible paths or procedures. • Appropriately clear addressing of texts and activities. • Activation by gestures and body movements. • The possibility to customise the presentation of information (urgent and non-urgent). • Elimination of flickering visual effects on the screen. • Reducing the visual angle of the area of repetitive patterns and the speed of this repetition. • Reduction of other light-sensitive triggers. • Alarm keys.

Deaf students and students with hard of hearing

- Using the keyboard (even without a mouse).
- Live 'texting' with online demonstration with live display of typed letters.
- Visual sound indicator while 'texting' in live texting.
- Alternatives for services requiring speech.
- Screen resolution and video image settings.
- Controls for subtitles and audio descriptions.
- Setting the volume of speech.
- Setting the volume of the audio.
- Incremental add and add audio volume.
- Enabling multiple different paths within the application to achieve a goal.
- The possibility to change time limits (extension).
- Use of pause, stop and hide functions.
- Allowing pause and stop pause, stop, pause, pause, pause, pause, pause.
- The possibility to return to the start position at any time.
- Focus guidance on control (display active elements).
- Clear headings and prompt phrases.
- Allowing flexible execution time tasks.

Students with motor disability / Students with reduced mobility

- Controls in the visual environment (at eye level).
- A control with a clear purpose and role.
- A control with a specific, appropriately powerful pressure (gently, harder).
- A suitably adapted keyboard with no hidden keys.
- Abbreviations for several keys in sequence.
- Time setting for entering individual characters.
- Allowing pause and stop of activity.
- Possibility to return to the start position at any time.
- Focus guidance on operation (display of active elements).
- Allowing several different paths in the application to reach a goal.
- Appropriately clear addressing of texts and activities.
- Activation by gestures and body movements.
- The possibility to customise the presented information (urgent and non-urgent).
- Alarm keys.

Debevc, M. (2021). Dostopnost digitalnih produktov za vse. [Digital products accessible to all.] University of Maribor – University Press.

Understandable area

Understandability refers to the ways to interpret the content correctly (Debevc, 2021). It is recommended (W3C Web Accessibility Initiative (WAI), 2018):

- To make text readable and understandable.
- To make content appear and operate in predictable ways.
- To help users avoid and correct mistakes.

The needs of individuals with SEN according to understandability are presented in the Table 3 below.

Table 3. *The needs of individuals with SEN according to understandability (Debevc, 2021)*

Students with specific learning difficulties
• Setting the language. • Consistently the same navigation and workflow within the app. • Labelling or instructions for entering data. • Automatically detecting errors and providing suggestions for correcting them.

Blind students / visually impaired students
• Setting the language. • Consistently the same navigation and workflow within the app. • Labelling or instructions for entering data. • Automatically detecting errors and providing suggestions for correcting them.

Deaf students and students with hard of hearing
• Setting the language. • Consistently the same navigation and workflow within the app. • Labelling or instructions for entering data. • Automatically detecting errors and providing suggestions for correcting them.

Students with motor disability / Students with reduced mobility
• Texts in the relevant language. • Simplified texts where necessary. • Labelling or instructions for entering data. • Correcting and pointing out errors.

Debevc, M. (2021). Dostopnost digitalnih produktov za vse. [Digital products accessible to all.] University of Maribor – University Press.

Robust area

In the context of robustness compatibility with current and future technologies is determined (Debevc, 2021). It is recommended (W3C Web Accessibility Initiative (WAI), 2018):

- To maximize compatibility with current and future user tools.

The needs of individuals with SEN according to robustness are presented in the Table 4 below.

Table 4. *The needs of individuals with SEN according to robustness (Debevc, 2021)*

Students with specific learning difficulties
• Breaking down content elements. • All features are unambiguous and clearly named. • Clear status messages.

Blind students / visually impaired students
• Breaking down content elements. • All features are unambiguous and clearly named. • Clear status messages.

Deaf students and students with hard of hearing
• Breaking down content elements. • All features are unambiguous and clearly named. • Clear status messages.

Students with motor disability / Students with reduced mobility
• Breaking down content elements. • All features are unambiguous and clearly named. • Clear status messages.

Debevc, M. (2021). Dostopnost digitalnih produktov za vse. [Digital products accessible to all.] University of Maribor – University Press.

Useful accommodations/adjustments for specific groups of students with SEN

The following text describes some useful accommodations/adjustments for specific groups of students with SEN.

Students with dyslexia

Table 5. *Useful accommodations/adjustments: Dyslexia*

Special educational needs	**Dyslexia** *(problems with reading and writing, retrieval of information, working memory, sequencing - procedural problems)*
Learning problems	**Reading problems** **Writing problems**
Accommodations/ Adjustments to be considered	• They are fine with avoiding the use of capital letters, italics and underlining of words, but it is a good idea to align the text to the left and to maintain a consistent layout (Debevc, 2021). • It is a good idea to avoid large chunks of condensed text and instead break up the text with images and diagrams (Debevc, 2021). • It helps if you provide automatic spelling corrections or suggestions (Debevc, 2021). • They find it difficult to do tasks that require recalling content from previous pages (it is good to use other formats e.g. audio or video) (Debevc, 2021). • They benefit from limiting the amount of information on the screen and adjusting the contrast (Debevc, 2021).

Some suggestions for optimising web site designs for students with specific learning disabilities (considering both performance and preferences) in general includes:

- Organise text information so the most important content is at the beginning (Williams & Hennig, 2015) what is in journalism known as the 'inverted pyramid' (e.g., Pottker, 2003, in Williams & Hennig, 2015).
- Consider visual presentation of the key elements in a narrative story with graphic organizers (story mapping), because it can enhance the reading comprehension of students with learning disabilities (Stetter & Hughes, 2010, in Fajardo Bravo et al., 2020).
- Provide text and image correlation and ensure that image is relevant to the text.
- Minimise the number of words and the density of text to reduce or keep page lengths short (Williams & Hennig, 2015).
- Use larger text size (browsers can be configured to display the size of their choice) (Williams & Hennig, 2015).
- Design a menu layout where all the entries are clearly visible on the page and horizontally arranged (Williams & Hennig, 2015).
- Note that related pictures will not automatically help students to understand better, especially in cases of abstract concepts (Williams & Hennig, 2015).

Students with dyslexia

Table 6. *Useful accommodations/adjustments: Autistic spectrum disorder*

Special educational needs	**Autistic spectrum disorder**
Learning problems	**Difficulties in flexibility of thinking, social communication problems, problems with social interaction**
Accommodations/ Adjustments to be considered	• They are not comfortable with the use of strong contrasting colours (use pastel colours instead) (Debevc, 2021). • It is good to express ourselves simply and avoid the use of icons and phrases (Debevc, 2021). • Instead of using large chunks of condensed text, it is a good idea to use simple sentences and bullet points (Debevc, 2021). • They benefit from a descriptive button link that is clear and predictable (e.g., "Upload image." instead of "Click here.") (Debevc, 2021). • It is important to use simple, organised, and consistent hat the layouts (Debevc, 2021).

Students with specific language impairments

Table 7. *Useful accommodations/adjustments: Specific language impairments*

Special educational needs	**Specific language impairments** *(problems with language comprehension and expression)*
Learning problems	**Language problems**
Accommodations/ Adjustments to be considered	• It is helpful for students with verbal apraxia that we use close-up video of the mouth movement (they can see the mouth structures and the mouth move while sounds are produced) (Green, 2018). • It is good to use multisensory stimuli (e. g. student hears words, sees words and images, can move items around for tactile input, and can record his or her voice); for some individuals, multi-sensory stimulation is overwhelming, they feel the best when only one sense is stimulated at a time (Green, 2018). • Pictures and words are shown in natural settings (students can see pictures of items in context or grouped by categories) (Green, 2018). • It is good to provide recording capability (many individuals with expressive deficits benefit from hearing recordings of their own speech immediately after they speak) (Green, 2018). • It is a good idea to use text readers and speech to text options (Green, 2018).

Blind students / visually impaired students

Table 8. *Useful accommodations/adjustments: Blind students / visually impaired students*

Special educational needs	**Blind students / visually impaired students**
Learning problems	**Visual problems**

Accommodations/ Adjustments to be considered	• It is useful to provide a screen reader, screen recognition systems etc. (Rodriguez & Arroyo, 2017, in Fajardo Bravo et al., 2020). • Provide descriptive scripts for videos (Fajardo Bravo et al., 2020). • It is good to know that only colour should not be used to convey the important content (some students might have difficulties to differentiate colours), thus underline the text instead (Fajardo Bravo et al., 2020). • It is important to consider contrast, lighting and brightness of the materials on the screen (Fajardo Bravo et al., 2020). **Blind students** • It is important to describe the images and provide transcripts of videos (Debevc, 2021). • They do well when linear, logical layout is followed (content should not be concentrated on the whole screen) (Debevc, 2021). • It is a good idea to prepare descriptive links and headings for the keyboard control (avoid exclusive use of mouse or screen) (Debevc, 2021). • They benefit from a descriptive button link that is clear and predictable (e.g., "Upload image." instead of "Click here.") (Debevc, 2021). • It is a good idea to structure the content using HTML 5 (rather than setting a fixed text size and its placement in the structure) (Debevc, 2021). **Visually impaired students** • They need appropriate colour contrast, legible and large enough fonts (e. g. the ability to zoom, change contrasts, colours, and font sizes) (Debevc, 2021). • They benefit from a combination of colour, shapes, and text (e.g., pictograms for a particular type of instruction) (Debevc, 2021). • They benefit from placing the button and the field (e.g., for typing) in context, rather than separated from a relevant context (Debevc, 2021). • It is good for them when all relevant information is published on the website and they do not need to download them to their devices (Debevc, 2021). • It is good for them to follow a linear layout and adapt the content to the screen width (e.g., when zoomed in, the lines are no longer than the width of the screen) (Debevc, 2021).

Deaf students / students with hard of hearing

Table 9. *Useful accommodations/adjustments: Deaf students / students with hard of hearing*

Special educational needs	**Deaf students / students with hard of hearing**
Learning problems	**Hearing problems**
Accommodations/ Adjustments to be considered	• They benefit from simple language (rather than using complicated words or icons) (Debevc, 2021). • It is good to have a simple menu and a linear, logical layout (avoid multi-level menus and complex layout of content) (Debevc, 2021). • You need to use subtitles or provide transcripts for videos or scripts (Debevc, 2021; Bess & Hornsby, 2014, in Fajardo Bravo et al., 2020). • They will benefit from the additional subheadings, images, and video content (avoid large chunks of condensed text) (Debevc, 2021). • It is useful to minimize the background noise (Bess & Hornsby, 2014, in Fajardo Bravo etc., 2020; Peelle, 2018, in Fajardo Bravo et al.). • Ensure that camera is switched on and the mouth is visible to facilitate lip-reading (Bess & Hornsby, 2014, in Fajardo Bravo et al., 2020). • It is good to provide important information in written form (exam dates, assignment info) (Bess & Hornsby, 2014, in Fajardo Bravo et al.).

Students with motor disability / students with reduced mobility

Table 10. *Useful accommodations/adjustments: Students with motor disability / students with reduced mobility*

Special educational needs	**Students with motor disability / students with reduced mobility**

Learning problems	**Problems with mobility**
Accommodations/ Adjustments to be considered	• They benefit from a larger area to click on for important actions (do not require a very precise click) (Debevc, 2021). • It is a good idea to avoid dynamic content that requires a lot of precise mouse movement, allow the use of keyboard or speech instead (Debevc, 2021). • It is a good idea to give enough space to the form field (the interactive fields should not be too close together) (Debevc, 2021). • They benefit from not being hampered by the short duration of the logged session (it is worth considering the content format in mobile touch devices) (Debevc, 2021). • It is good to provide shortcuts (not too much scrolling and typing) (Debevc, 2021).

About the Teacher's Book

About materials for students and the role of the book for teachers

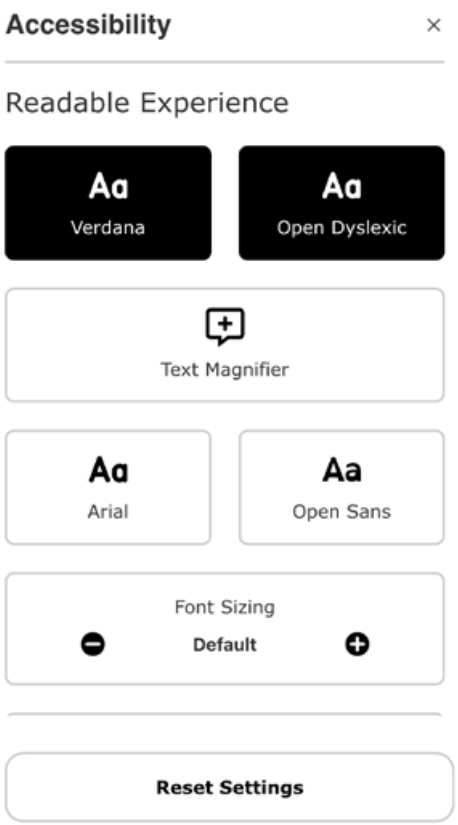
The "Teacher's Book" is designed to accompany a collection of additional and complementary interactive materials for teachers of the students with SEN for physics lessons.
The ARphymedes Plus portal includes interactive teaching materials for physics, enriched with educational films, animations, and interactive tasks to help students with SEN to build up their knowledge. The interactive material on the portal for students with SEN is a collection of activities that complements, enhances, and enriches the regular textbook material. This is where the Augmented Reality (AR) elements stand out, represent the modern approach to teaching, and are an attractive and motivating addition for young people. The experimental work is put at the forefront and is linked to the students' experience.
Teachers can use a digital and interactive content tailored to the needs of students with SEN, to capture their attention and present the content of physics effectively. The portal also has additional functionalities that allow to tailor the learning process to the individual needs as well as the learning pace SEN students.

Accessibility Toolkit

As students with different disabilities learn differently, the learning material on the ARphymedes Plus platform is tailored to their learning styles and the accessibility tools allow them further personalization of the content.
The ARphymedes Plus online learning platform provides a personalised learning environment by customising content, and using universal design principles including:

- Text-to-speech and video subtitles.
- A print to Braille conversion function.
- Customised organisation of content (special highlighting of new terms, highlighting of key information, chapter summaries, mind maps).
- Typographic customisation of text (font selection, size selection, contrast adjustment, background adjustment).
- Organising the structure of the text (dividing the learning content into smaller parts).
- Enhanced interaction features (one-click navigation, voice-guided navigation, touch sensitivity, mouse sensitivity, etc.).

Figure 1
Accessibility tv oolbar on the ARphymedes Plus platform (right side of the screen)



List of tools in the accessibility toolbar:

Text magnifier
By pressing the command, you can enlarge any text.

Type of font
By pressing the command, you can change the font format.

Font sizing
You can increase or decrease the font size by pressing the command.

Line height
This command can be used to change the line spacing (press - to decrease the spacing, + to increase the spacing).

Letter spacing
This command can be used to change the spacing between letters.

(pressing – decreases the spacing, pressing + increases the spacing).

Dark contrast
Command to change a light background to black and a black font to white.

Adjusting the background colour
By selecting a colour on the command, you can change the background colour to your preference.

Hiding images
This command can be used to hide all images on a web page, only the text is visible.

Reading guide
Moving the reading guide - the ruler - helps you to keep from getting lost in the line and between the lines.

Reading mask
This command highlights only a narrow band of text.

Big dark cursor

Big light cursor

Figure 2
Accessibility toolbar on the ARphymedes Plus platform (left side of the screen)

Tools in the accessibility toolbar:

Freehand drawing command

Arrow drawing command

Eraser erasing command

Eraser erasing command

Introduction of the Physics Chapters

This chapter of the Teacher's Book focuses on presenting the individual chapters of the e-book for students (interactive e-Student's Book), which can be found on the project website https://studentbook.arphymedes-plus.eu/.

As mentioned above in the introduction, this Teacher's Book is based on the materials of the ARpyhmedes project, so this chapter of the Teacher's Book is also a modification of the ARphymedes Teacher's Book to fit the context of the ARphymedes Plus project.

The chapter of the Teacher's Book entitled "Introduction to Physics Chapters", consists of 5 chapters with the same titles as the chapters in the Student's e-Book. Each chapter begins with a summary of the content, an interesting note about the selected representative -scientist, followed by the part Learning objectives and examples of Tasks for a knowledge test. Detailed descriptions of the lives and work of scientists can be found in various reference works, also in the Stanford Encyclopedia of Philosophy. The suggested tasks can be adapted to students with special characteristics.

Chapter 1

What is Physics?

Chapter 1: **What is Physics?**

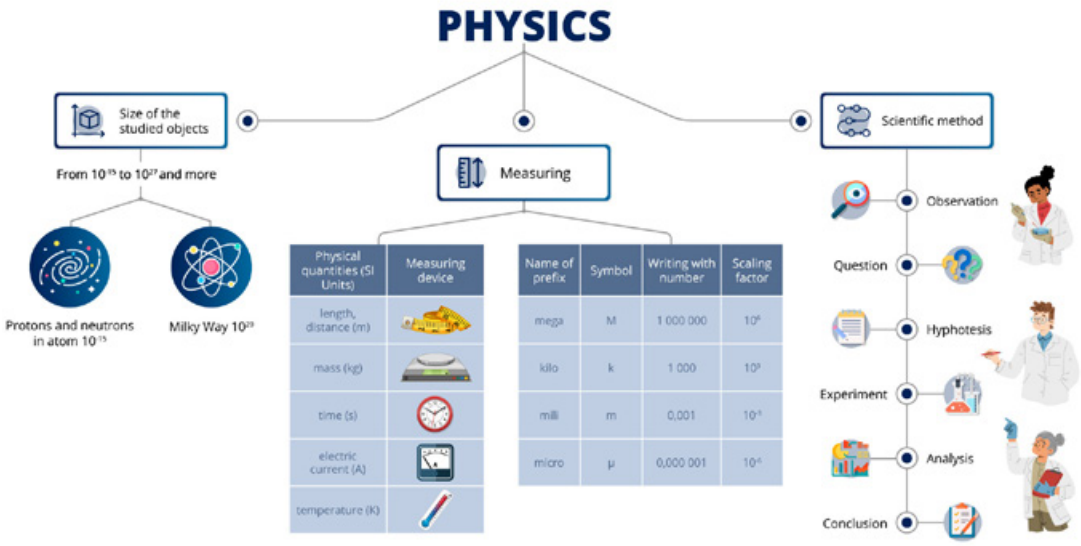
Natural sciences in general, and physics included is a rational endeavour based on valid experimental evidence, criticism, and rational discussion. Physics provides us with knowledge about the physical world, and the experiments provide us with the evidence grounded in knowledge. Experiments play many roles in science. One of the most important roles is to test theories and provide the basis for scientific knowledge (Franklin and Perovic, 2023).

Let us start from the very beginning. The name of physics comes from Ancient Greece. In ancient Greek the word meant "doctrine of nature." Physics is the fundamental branch of science that studies matter and energy, and their mutual influences. It describes the universe from the smallest dimension to the largest dimension as you can imagine. It describes what happens at the sub-microscopic level, but also at the level of the whole universe size. Physics is related to other branches of science in which research continuously raises new questions that further lead to next research. Theories have also been changed, improved, and combined throughout the history of physics. For example, Newton unified the mechanics of space bodies with the mechanics of bodies on Earth as well as in the laboratory. Oersted unified electricity and magnetism, Maxwell unified electricity and optics. Quantum mechanics combines and unifies mechanics and chemistry. Thus, in physics the knowledge is being built, and we never know when a new discovery emerges to change or add something to current knowledge or existing theories that describe our observations and measurements in nature.

In the chapter "What is Physics?" students gain the insight into what physics describes, how physics is integrated into different branches of science, and what areas of our lives it affects. They learn what tools are used to describe phenomena and how theorems, laws, equations, and units are expressed and written in physics.

A tiny insight into physics is given by a picture in the Student´s e-Book.

Figure 3
Origami of physics



Learning objectives

Students will:

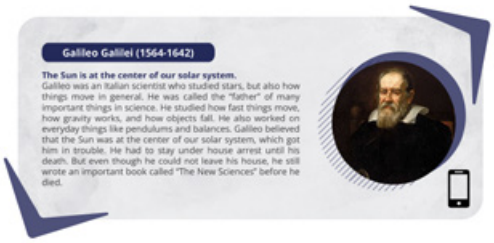
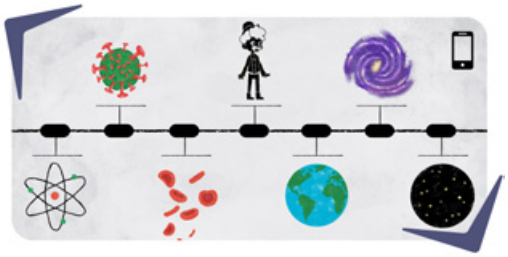
- discover the importance of experimentation in learning and verifying physical laws.
- learn the importance of combining experimental knowledge with theoretical, analytical, and synthetic thinking.
- learn about the indivisibility of the measurement in numbers and units, and that the values of physical quantities, as their product, must always be written.
- recognize the importance and indispensability of physical knowledge for technological development and mastery of nature.
- learn to evaluate the scientific achievements of physics, their impact on the changed living conditions and the progress of society, and general culture.
- learn and apply following methods and forms of work in physics (scientific methods): observing, planning, measuring, experimenting, drawing conclusions, interpreting measurements and experimental results.
- define the terms: physical quantity, physical unit and measuring device.
- recognize selected physical quantities.
- adopt prefixes, recognize conversions between units of measurement and used prefixes.
- compare the dimensions of the atom and other microscopic particles with the dimensions in the universe (Verovnik et al., 2011).

Point of interest

Galileo Galilei was an important figure in the history of physics. Here are some interesting facts about his work. With his revolutionary thoughts and works Galileo Galilei (1564-1642) paved the way for the scientific progress of the Renaissance and the Enlightenment. He was born in Pisa, a city famous for its leaning tower. He had a remarkable influence on the development of astronomy, being the first to observe the celestial bodies with binoculars systematically, where the binoculars with sharpened lenses were made by himself, following the Dutch model. He described the tides and presented a view of the heliocentric system. After the book "Dialogues" was published, Galileo was put on trial in Rome, as the court, presided over by the Pope, made a strict decision. Galileo was threatened with torture if he did not renounce the "error and heresy about the motion of the Earth". He was sentenced to home arrest and surveillance. Nevertheless, he continued to create and research. He is credited with the famous saying "And yet it moves", a reference to what he believed in, even to stay alive he had to deny his beliefs. His research and study were focused on the motion of bodies, and the motion of free-falling bodies. Although he is often said to have dropped bodies from the Leaning Tower of Pisa, but researchers in the history of physics believe that Galileo Galilei did not do that. He was among the first to conduct systematic experiments, which he planned, performed thoughtfully, and sometimes predicted the results based on reasoning. Interesting is to note that he conducted the experiments with a ball rolling down the slope while singing, where the beat of the song was also the measure of time. He attached strings to the ramp, and as the ball was rolling, it made a sound (a beat) each time it rolled over the string. While he was singing, he managed to arrange the strings so that they were struck one after the other at equal intervals. In addition to singing, he used his heartbeat to time himself (Strnad, 2003).

Experiments and animations

See the table below for the list of animations included in the Student's Book.

A brief description of the experiment or animation	Figure/trigger
Animation on Galileo Galilei in Pisa	
Animation on orders of magnitude from the smallest to the dimensions of the universe	

Examples of tasks for the knowledge test

Task 1 verifies, whether the students can relate a real measurement example to the measuring device. The task can be modified to reduce the number of examples and/or include pictures for the measuring devices.

Task 2 is similar, and students must identify physical quantities and units from context and show their relevance to life.

Task 3 tests, whether the student can design an experiment to determine the average stride length as accurately as possible.

In physics, it is important that students also practice converting units to test the knowledge of prefixes, covered in Task 4.

Task 1

Connect the measured quantities to the appropriate measuring device.

MEASURED QUANTITY	MEASURING DEVICE
The mass of a box of apples	Stopwatch
Thickness of the drill	Tape measure
Water temperature	Scale
Running time for 60 metres	Thermometer
Table length	Speedometer
Speed of a car	Beak metre

Task 2

Fill the gaps.

Peter measured _____from home to school with steps.

He took 800 steps. He measured _____ with his watch.

He walked 10 _____ to school.

At school he weighed _____ textbooks and measured 200 ____.

Task 3

Describe how you would determine your average stride length.

Task 4

Convert units:

0,012 km = _____ m

0,027 kg = _____ g

30 min = _____ s

0,027 kg = _____ g

40 cm2 = _____ m2

2 m3 = _____ cm3

2700 kg/m3 = _____ g/cm3

Chapter 2

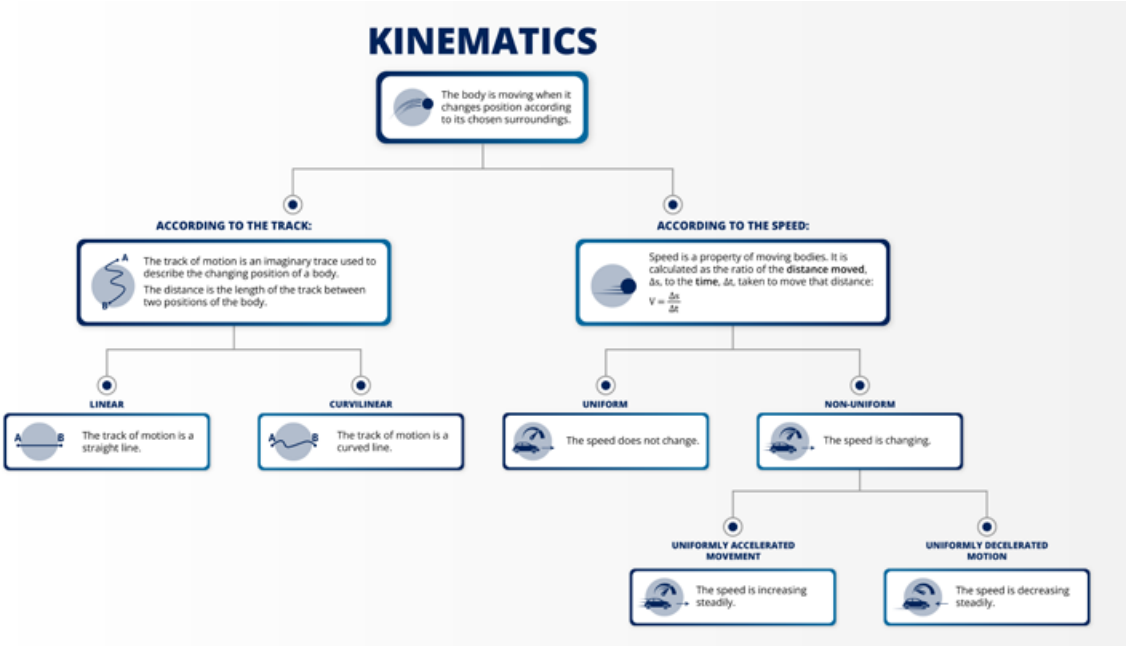
Kinematics

Chapter 2: **Kinematics**

Mechanics is the branch of physics that describes the motion or rest of bodies. Kinematics is a sub-branch of mechanics that describes the motion of bodies in an observed system. Both, the observation system as well as the coordinate system, play important roles. Incidentally, the term kinematics is derived from the Greek word kinematos, which means motion. Emphasised is that it deals with the description of the bodies in space and their motion, independent from the causes of the motion.

In the Student´s e-Book , Chapter Kinematics, students will identify the motion of bodies through animations and deepen their knowledge on the use of graphic representations of motion. Primarily they will address the motion in terms of track and speed, how to calculate velocity, how to present motion using tables and graphs, as well as uniform and non-uniform motion. The following figure was created to illustrate important concepts and overviews of the content.

Figure 4
Origami of kinematics



Learning objectives

Students will:

- define the difference between the movement and rest of the observed object in relation to the surroundings.
- describe straight and curved motion.
- learn that speed is the quotient of distance and time.
- use the equation to calculate speed.
- describe a uniform and a non-uniform motion.
- recognize the graph showing dependence of the path on time, read the data from it, explain it, and understand what type of motion it represents.
- recognize a graph that shows the dependence of body speed on time, read the data from the graph, explain the graph, and understand what type of motion the graph represents.
- calculate unknown quantities using the graphs.
- know that the acceleration is the ratio between speed and time (Verovnik et al., 2011).

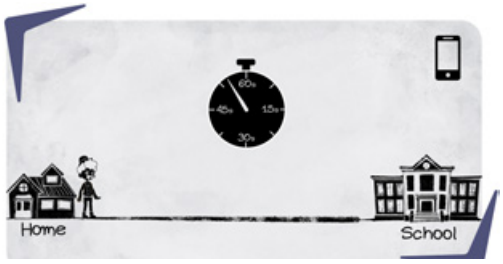
Point of interest

The French mathematician and philosopher Rene Descartes (1596-1650) was an important figure in the history of physics. Much of his attention was devoted to the Cartesian coordinate system and its application. Even today, the coordinate system is a mathematical tool and the basis for describing motion. Moreover, people were not aware of how much he contributed to physics. Until the second half of the twentieth century, he was generally underestimated and under-researched by both historians and philosophers of science. Descartes not only provided the first uniquely modern formulation of the laws of nature and a conservation principle of motion, but he also constructed the most popular theory of planetary motion in the late 17th century (Slowik, 2021).

Experiments and animations

See the table below for a list of animations included in the Student's Book.

Table 12. *List of trigger images or videos of animations and experiments in the chapter "Motion"*

A brief description of the experiment or animation	Figure/trigger
Animation on the concept of position	
Animation of the introduction of the concept of speed	

Examples of tasks for the knowledge test

Task 1 determines whether students recognize examples of curvilinear motion that provide insight into the distinction between linear and curvilinear motion of objects. The task may be modified to reduce the number of examples or to use pictorial illustrations.

Task 2 tests whether students can describe if the example object under consideration is in motion and at rest related to its surroundings.

The ability to calculate the speed and draw the graph of distance and time is the content of Task 3.

Task 4 checks whether students know how to calculate the speed and convert it from one unit to another.

Task 1

Among the given examples of motion, mark those in which the object motion is curvilinear.

Example	Curvilinear motion
1. Discus throwing.	
2. Rally driving.	
3. Pears falling from a tree.	
4. Landing of an aeroplane at the airport.	
5. Riding a motorcycle on a straight road.	
6. The movement of the planets around the sun.	
7. An athlete competes in running on 100 m.	

Task 2

In the description of the event, the observed body is underlined. Select from its surroundings the body to which it is at rest and the body to which it is moving.

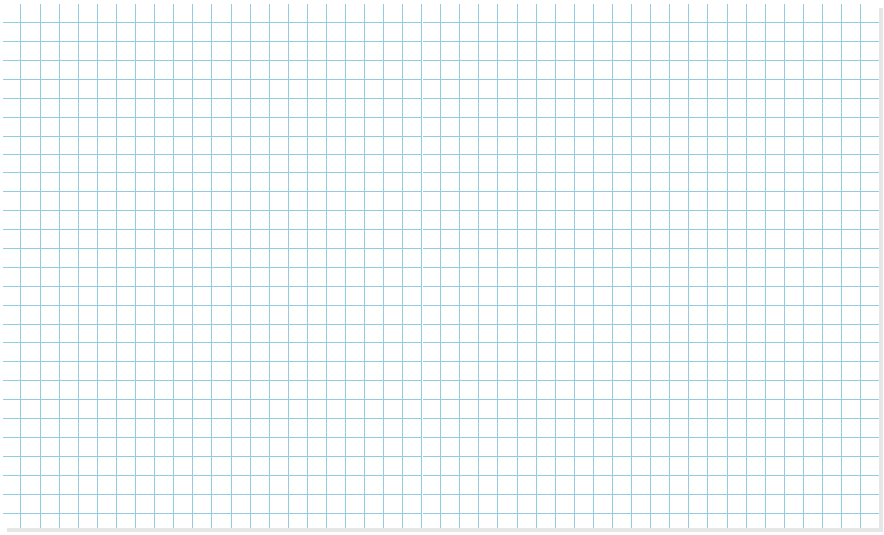
Event	At rest according to ...	Moving according to ...
A passenger is sitting on the bus on the way from Ljubljana to Piran.		
Mihael is riding a bike and has a helmet on his head.		

Task 3

The table below shows the distances covered by the marathon runner in specific times. The marathon runner moved at a steady pace.

- The speed of the marathon runner is _____.
- Draw a graph of the dependence of distance on time.
- What distance does a marathon runner cover in 25 minutes? Show that computationally and graphically in a plotted graph.

t [min]	10	20	30	40	50
s [km]	3,6	7,2	10,8	14,4	18



Task 4

What are their speeds? Write the answers in m/s or km/h.

- Snail travels 25 meters in 24 hours.
- A cyclist covers 30 kilometres in one hour.
- A greyhound runs 4 kilometres in 320 seconds.
- Tina runs 2400 meters in 12 minutes.

Chapter 3

Forces

Chapter 3: **Forces**

Mechanics is the branch of physics that describes objects in motion or at rest. Dynamics is a branch of mechanics that describes the motion of bodies under the influence of forces and torques. In this chapter, students use animations to identify bodies at rest and bodies in motion to reinforce their knowledge of Newton's laws.

In this chapter, students learn how to describe forces, how to measure forces, how to draw forces, how to add forces, and how to explain Newton's three laws and their application in examples.

Learning objectives

Students will:

- define the concepts of observed body and surroundings.
- realize that forces are the cause of a change in the motion or shape of a body.
- name forces after the bodies that cause them.
- distinguish between forces that act on contact and forces that act at a distance.
- introduce the unit of force newton (N).
- find out that forces of equal magnitude on the selected body cause the same effects.
- present the force with a line segment in the selected scale.
- take over the fact that the point of application of the forces can be punctual, areal, or spatially distributed.
- draw the forces from the point of application.
- determine whether the forces acting on the body are in balance.
- understand that if the forces acting on the body are in balance, the body is at rest or in the uniform motion.
- understand that the forces of friction and air resistance oppose the motion.
- describe the force of friction.
- figure out that bodies interact.
- analyse cases and distinguish the law of interaction (Newton's 3rd law) from the law of equilibrium (Newton's 1st law) (Verovnik et al., 2011).

Point of interest

Isaac Newton (1643-1727) is one of the most famous physicists of all time. When the editors of Physics World magazine asked all the physicists round the world which five physicists contributed the most to physics, the results showed that Isaac Newton was the second in terms of number of citations, right after Albert Einstein (Strnad, 2000).

Newton's worldview and the correspondence of his thoughts and writings to the phenomena of nature were extraordinary. He worked in all branches of physics of his time, and his greatest contribution to science was in the field of mechanics. He was the first in the history of physics development to establish the first internally consistent physical theory, which is to some extent still valid today (Strnad, 2003). His laws are known to the entire population in primary education. Newton recognised that a force (gravitational force) must act between two bodies. He also recognised that the same force is at play when we talk about the orbit of the Sun and when an apple falling to the ground is described.

Newton published his three laws of motion in the "Philosophiæ Naturalis Principia Mathematica", published in Latin in 1687 (Newton, 1846). The laws read in English:

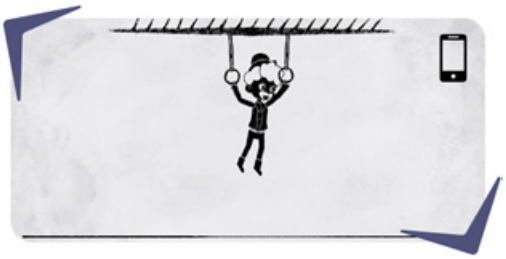
- Newton's First Law: Every body remains in its state of rest or in a uniform motion along a straight line unless it is forced to change this state by forces acting on it.
- Newton's second law: The change of motion is always proportional to the force acting on it and occurs in the direction of the straight line in which this force acts.
- Third Newton's law: Every action is always opposed by an equivalent reaction; or the reciprocal actions of two bodies on each other are always equal and directed to opposite parts.

Experiments and animations

See the table below for a list of animations included in the Student's Book.

Table 13

List of trigger images or videos of animations and experiments in the chapter "Forces"

A brief description of the experiment or animation	Figure/trigger
Forces are at balance	

Motion of the ball

Forces on the shopping chart

Examples of tasks for the knowledge test

Task 1 determines whether students recognize examples of points of application by forces.

The overall representation of forces is examined in Task 2. At the same time, the assignment of weight to bodies with known mass or vice versa is tested here.

Task 3 tests the understanding of Newton's laws.

Task 4 reviews drawing and adding forces and observing Newton's laws.

Task 1

Mark in the table (with a cross) how the following forces are distributed.

Example	Point	Planar	Spatial
The force of the magnet on the pin.			
The force of the pen tip writing on the paper.			
The force of the geotriangle on the table.			

Task 2

The student is holding a backpack, as shown in the picture.

The weight of the backpack is 20 N. Determine the magnitude, direction, and point of application of the forces acting on the backpack and draw them to scale.

What is the mass of the backpack?

Task 3

Are the statements correct? On the line write T (true) if the statement is correct and F (false) if it is incorrect.

_____ An apple is hanging from a branch. The resultant of the forces acting on the apple is equal to the weight of the apple.

_____ The car is in front of a traffic light. The sum of all forces acting on the car is zero.

_____ The car is moving smoothly on a straight road. The resultant of all forces acting on the car is equal to the force of the engine.

_____ We hang a weight of 4 N on a spring balance attached to a tripod. It expands by 2 cm. At the end, the resultant of the forces acting on the weight is zero.

_____ There is a plate on the table. Since it is at rest, no force acts on it.

Task 4

A skier steps on soft snow. His weight is 600 N. In the moment he steps on the snow, the ground force on the skier is 400 N.

What is the size of the resultant force and in which direction does it act?

What force must be changed for the skier to keep at rest?

Add up the forces graphically as well on the figure below. Do not forget the scale.

Chapter 4

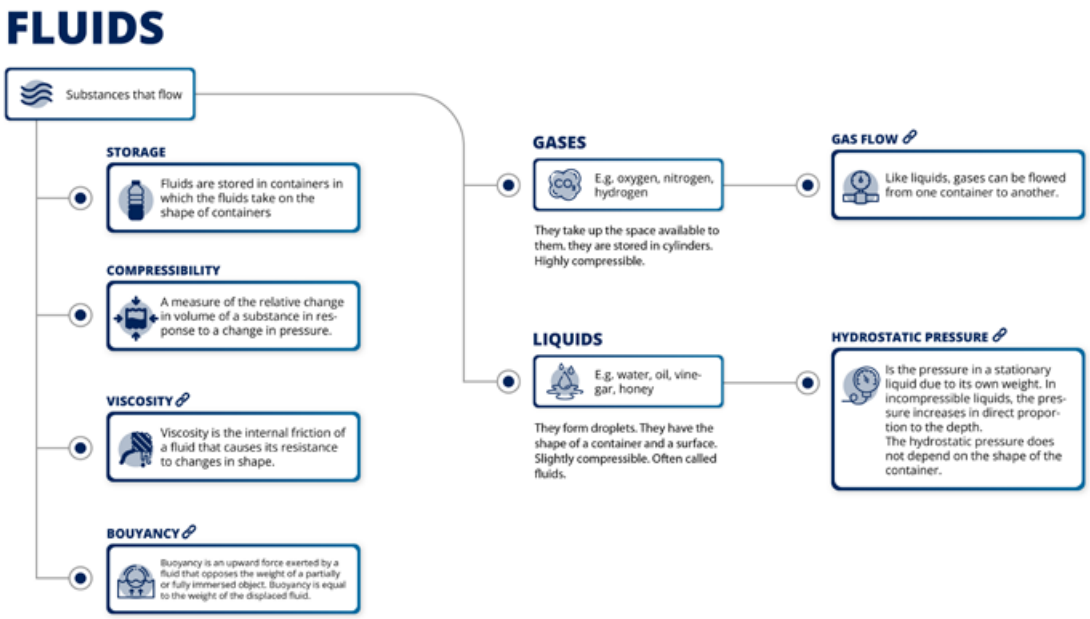
Fluids

Chapter 4: **Fluids**

Fluids are divided into liquids and gases. They flow under the influence of pressure differences. Gases are stored in closed containers because they occupy all the space available to them. Gases are more compressible than liquids. Fluid mechanics is a special branch of science that describes the properties of fluids at rest and the reactions of fluids when acted upon by various forces. The properties of fluids in motion are described in a sub-branch of science called fluid dynamics.

In the chapter of the Student´s e-Book "Liquids", students will learn about fluids. They will learn and investigate their properties, hydrostatic pressure, and buoyancy. The main idea of the chapter in the Student´s e-Book is shown in the figure below.

Figure 5
Origami of fluids



Learning objectives

Students will:

- know that liquids flow.
- demonstrate that gases are liquids.
- observe the selected animation/experiments to learn and apply the methods and forms of work in physics, focusing on observation and interpretation of measurements and experimental results.
- develop the understanding of viscosity concept, and the temperature dependence of viscosity through experimenting with different fluids.
- identify what the pressure in a still fluid depends on.
- investigate buoyancy through experiment.
- formulate Archimedes' principle and apply it to a concrete example.
- know that pressure in liquids increases with depth (Verovnik et al., 2011).

Point of interest

Archimedes is an important scientist, who is also the starting point for the acronym of the ARphymedes Plus project, where his role the field of the history of physics is crucial.

Archimedes (287-212 BC) from Syracuse in Sicily summarised, edited, and extended the knowledge of statics in his time. He was a very important mathematician and physicist of the ancient world. He worked in Alexandria. We will also cover him in the chapter that deals with working with tools. Archimedes' lever theorem states that a symmetrical and symmetrically loaded lever is in equilibrium, and that a force equal to the total weight of all the loads acts vertically upward in the axis. Then he combined the loads on one and the other side asymmetrically and repositioned their anchors accordingly. He used the concept of the centre of gravity. This research prompted Archimedes to say, "Give me a fixed point, and I will lift the Earth" (Strnad, 2003).

On the other hand, we have mentioned him in this chapter "Fluids" because he is commonly associated with the story of King Hieron, who is said to have had a golden crown made. He suspected that the goldsmith had deceived him. Archimedes is said to have realised how to justify his suspicions. It is said that he weighed the crown, then made a piece of gold of the same weight and another piece of silver of the same weight. Then he measured the volume of the crown by dipping it into a bucket filled with water and determined the volume of the spilled water that had flowed from the bucket. The volume of water displaced by the crown is equal to the volume of water displaced by the gold if the crown was made of pure gold. However, it turned out that the volume of the crown was larger than the volume of the gold and smaller than the volume of the silver. It was suspected that the goldsmith had added silver to the gold. So, Archimedes introduced a specific volume and a specific weight, and gave the possibility to measure them.

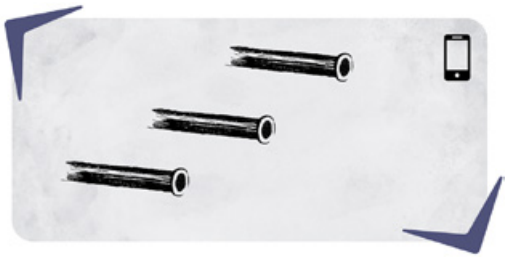
Archimedes also derived the principle of buoyancy. Archimedes did not report on the devices he built. It is reported that he built a water screw on the Egyptian model to lift water. He built devices for throwing projectiles (called Greek fire) based on a lever, and he gained the trust of his fellow citizens when he used levers to move a ship, although no one had previously believed that this was possible.

Experiments and animations

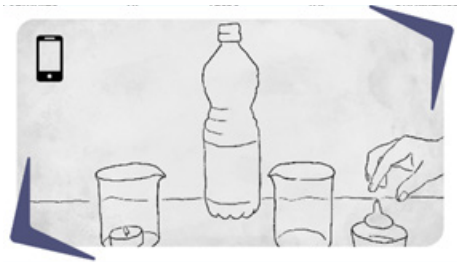
The table below shows the list of animations as they appear in the student materials.

Table 14

List of trigger images in the chapter "Fluids"

A brief description of the experiment or animation	Figure/trigger
Animation about Archimedes and the Crown	
Animation Viscosity of water, oil and honey.	
Animation Demonstration of the connecting vessels/tubes characteristics.	

Experiment
Gas flow



Examples of tasks for knowledge test

Task 1 tests students' knowledge on the types of substances. Students must independently classify substances into three groups and write down the names of the types of substances. The most common choice is to divide substances into solids, liquids, and gases.

Task 2, based on the text, guides students to distinguish important from unimportant actions and to create awareness of the importance of conducting a fair experiment on the viscosity of liquids.

Task 3 relates to knowledge of the fact that hydrostatic pressure depends only on depth and not on the shape of the container. In the second part of the task, students must design an experiment to demonstrate that, what is a more challenging task. They can recall the treatment of material flow, and the shape of a liquid jet as it flows out.

Task 4 tests knowledge on buoyancy using concrete and simple examples that must be evaluated by students.

Task 1

Classify the written substances into three groups according to the type of substance. Also write the type of substance in the first row of the table.

WOOD, OIL, OXYGEN, PAPER, WATER, CARBON DIOXIDE, CLAY, JUICE, HELIUM, GLASS, MILK, AIR, RUBBER, ALCOHOL, BUTANE

Task 2

Read the plan for conducting the classroom liquids viscosity inquiry. Is conducting the experiment in the described manner fair? Give reasons for your answer.

Form groups of four and give each group a choice of four liquids to test in taped cups.

1. Each student competes the other three. First, student 1 competes student 2, while 3 competes 4.
2. Students simply tip their cups at the same time and watch closely until all the liquid has flowed from one container to the other. They should write down which liquid was faster and which slower.
3. Next, have student 1 competes student 3 and student 2 competes student 4. Again, they note the faster and slower liquids.
4. Finally, student 1 competes student 4 and student 2 competes student 3. They write down the results.
5. The group should be able to arrange the liquids in order of viscosity from lowest (fastest) to highest (slowest).

Task 3

Is the pressure at a certain depth of the liquid the same if we have different shapes of containers? Write down the design of an experiment to verify this.

Task 4

Are the statements correct? On the line write T (true) if the statement is correct and F (false) if it is incorrect.

_____ The unit for buoyancy is N.
_____ The buoyancy acts to a rock immersed in water.
_____ The buoyant force acts vertically upwards.
_____ The buoyancy is equal to the weight of the displaced liquid.
_____ The buoyancy is equal to the body weight.
_____ If salt is added to the water, the buoyancy on the ping pong ball increases.
_____ The buoyancy depends on the density of the liquid.
_____ The buoyant force is equal to the weight of the liquid in the basin.

Chapter 5

Work, Power, Energy

Chapter 5: **Work, Power, Energy**

Work, power, and energy are very important concepts in physics. These terms are frequently used in our daily lives. In physics, we use them in a slightly different way.

Work is an energy transferred to or comes from an object by a force acting on it. The energy transferred to an object is a positive work, and the energy transferred from an object is negative work (Halliday et al., 2001).

The time that a force does work is called the power due to the force. If by a force a certain amount of work is done in a certain amount of time (Halliday et al., 2001).

In Greek, the word energy means activity, by which Aristotle meant the transition from the possible to the actual. In all languages, the word was associated with the activity and vitality of humans and other living things. It was not until the 19th century that it acquired a physical meaning (Strnad, 2003). In physics, however, the concept of energy is so broad that a clear definition is difficult to formulate. Technically, energy is a quantity associated with the state or condition of one or more objects (Halliday et al, 2001). To describe energy, a system must be defined. The system may contain one or more objects. Energy is a quantity expressed by the number and the unit (joules) that relates to a system.

In this chapter, "Work, Power, Energy," students will learn the physical understanding of work, energy, and power through examples and apply them to examples from everyday life.

Point of interest

The unit for work, energy and heat is the joule. It is named after the scientist James Prescott Joule (1818-1889). He was the son of a wealthy brewer, so he could afford his own laboratory. In the laboratory he devoted himself to physical research, as he was very good at experimental work. He first worked on electricity and magnetism and continued to research heat and temperature. He measured heat in a variety of changes, for example, when water falls in a waterfall, when water is mixed or flows through pipes, when gases are compressed. He measured the mechanical equivalent of heat. Since he was not a physicist, at first his work did not attract much attention. It was not until Lord Kelvin, Michael Faraday and others became aware of his work, and supported it that he was made a Fellow of the Royal Society. The unit for energy, work and heat was introduced much later in his honour (Strnad, 2003, 1990, von Laue, 1982).

Learning objectives

Students will:

- explain that physical work depends on the force and the distance over which the force acts on the object.
- use the equation to calculate work and become familiar with the unit.
- understand that a force acting perpendicular to the direction of motion does not exert work on the object.
- recognize among the forces acting on a moving body the forces or components of forces that do work.
- know that kinetic energy is related to motion and that a change in kinetic energy is related to a change in speed.
- know that kinetic energy depends on the mass and speed of the body.
- use the equation to calculate kinetic energy.
- explain that the change in potential energy is related to the change in position of the body in the vertical direction.
- apply the equation to calculate the change in potential energy.
- understand and apply the theorem of conservation of mechanical energy.
- explain that the energy can be converted from one form to another.
- define power as the quotient of work and time in which the work is done (Verovnik et al., 2011).

Experiments and animations

See the table below for a list of animations included in the Student's Book.

Table 15

List of trigger images or videos of animations and experiments in the chapter "Work, power, energy"

A brief description of the experiment or animation	Figure/trigger
The work done when the object is pushed from A to B parallel to the base	

The work done by first applying the force of Arphy and the force of his friend on the object

The work done in pushing the object in different directions

Examples of tasks for knowledge test

Task 1 tests whether students know how to calculate work for a given force and distance. Below, they still need to convert the units and calculate the force given the work.

In Task 2, students assign a type of energy to objects from life and how it changes.

Task 3 involves knowledge of kinetic energy and awareness of the dependence of a body's kinetic energy on its speed.

Task 1

A worker pushes a cart 50 m with a force of 300 N.

a) How much work does the worker do? _____, that is _____ kJ.

b) How far would the cart have to be pushed with the same force to do 0.3 MJ of work? _____.

Space for accounts:

Task 2

What form of energy changes to the bodies written in bold and how does it change? Fill in the table. The first case is solved.

Event	Energy increases, decreases, does not change
The elevator lifts the **crate**.	The potential energy of the crate increases.
You bend a young **branch**.	
The **soccer ball** stopped for a moment in the net.	
You move the **pot** that is standing on the floor to another place in the room and place it on the floor.	
The carousel **seats** move faster and faster.	
The **parachutist** descends steadily towards the ground.	

Task 3

A ship with a mass of 8t sails across the sea at a speed of 18 km/h.

What is the kinetic energy of the ship?

Fill in.
If the speed of a ship with the same mass were 3 times larger, the kinetic energy of the ship would be _____ times larger.

Task 4

Calculate the power required to lift a bag of food from the floor to the kitchen counter. The bag of food weighs 6 kg, the height of the counter is 85 cm, and you lift it in two seconds.

General guidelines for paper textbooks and e-books

Paper

The appropriate paper thickness (thick enough to prevent the other side from showing through).

Matte, nonglossy paper, and single colour backgrounds.

Content organization

Clear table of content.

Alphabetical index of main terms.

A clear presentation chapter of the textbook, with clearly explained components of individual chapters.

Repetition questions at the end of the chapter.

Clear and comprehensive introduction at the beginning of each chapter (in the box, mind maps).

Comprehensive summaries at the end of the chapter (in the box, mind maps).

New terms and concepts are specifically marked and explained in the context between the text and in the glossary.

In the textbook, new terms and concepts are specially marked and explained with synonyms in the text.

Key information within individual chapters is written in boxes or is separated from other information.

The typography of the text

Sans serif fonts, such as Arial, Comic Sans, Verdana, Tahoma, Century Gothic, Trebuchet, Calibri, Open Sans.

Font size should be 12-14 point or equivalent (e.g. 1-1.2em / 16-19 px).

Text without underlining and italics.

Use of lowercase letters except for capitalization.

The titles of chapters and subchapters are written in lower case letters and are 20% larger than the rest of the text.

A maximum of two different fonts is used on a sheet of paper (e.g. one format for the title, the other for the rest of the content).

At least 1.5 line spacing.

The spacing between the title and the new paragraph is larger than the spacing between the lines. Clear, large enough spacing between the individual topics.

Appropriate contrast between the background and the text (the text is dark on a lighter (not white) background).

The background of the text is monochrome, free of patterns, pictures, or other distracting surroundings.

Avoid green and red/pink, as these colours are difficult for those who have colour vision deficiencies (colour blindness).

Left aligns text, without justification.

Lines should not be too long: 60 to 70 characters.

Avoid multiple columns (as used in newspapers).

Structure of the text

The text is presented in tables, indents, numbered, written in the form of a list (e.g. advantages and disadvantages, similarities and differences...), written in boxes or displayed in various graphical representations (for a clearer presentation of information, emphasis on essential information).

The text is arranged in a logical sequence (information follows from general to more specific, from known to new/unknown, from simple to more complex).

Within the chapters, longer texts are divided into subheadings, which divide the text in a meaningful way and enable easier orientation.

The layout within the chapters is consistent.

The titles and subtitles of the chapters are semantically strong (they predict the main topic of the following text) and contribute to the understanding of the content.

The paragraphs in the text of the individual chapters are short (between 5 and 7 lines) and separated by spaces.

The paragraphs follow each other within chapters in a logical sequence and are meaningfully interconnected.

Language and writing style

The length of the sentence is between 15 and 20 words.

Sentences are simple (simple) and direct, with minimal use of conjunctions.

A simple sentence syntax is used, which enables good understanding (without the use of extremely demanding professional words, the meaning of which is unexplained).

Concisely presented substance, without long and complicated paragraphs.

Sentences do not contain a double negative.

Use active rather than passive voice.

Unambiguous use of pronouns in the text.

Minimal use of abbreviations, acronyms, jargon, foreign words.

A clear explanation of the abbreviations, acronyms, jargon, foreign words, technical terms, unknown terms in the dictionary.

Minimal use of transferred meanings, metaphors that are not directly related to the subject matter.

In the case of the use of transferred meanings, a clear explanation is offered.

The interpretation of concepts is supported by real-life examples that students can relate to their experience.

Definitions are given and explained in context and easy to understand.

Explanations and examples are clear and understandable.

Clear instructions.

The complexity of the text is appropriate for the age level of the students.

Pictorial material and graphic illustrations

The text is supplemented with pictorial material (photographs, pictures, graphs, diagrams, displays, maps, tables).

Non-verbal or pictorial parts help to understand the content better.

Non-verbal parts (maps, tables, graphs, diagrams, etc.) are appropriate in terms of content and authenticity.

Images and other graphic content are provided with brief descriptions and explanations of their content (e.g., legend and interpretation of symbols on the map, description below photographs...).

The non-verbal parts are of appropriate size, clear and transparent, and without unnecessary details that would distract attention.

The layout of visual, graphic illustrations is logical, so it adequately supports the information given in the text and does not hinder reading.

Descriptions of the pictorial material are located below the pictorial material.

Symbols and other graphic symbols are used for easier orientation in the textbook/text, the meaning of which is presented in the added legend.

Illustrative diagrams of their course are used to explain and clarify the procedures.

Students with special needs – characteristics and guidelines for classroom and individual work

To work effectively and efficiently in an inclusive environment, crucial is to understand what each individual learner needs to be successful in learning. Therefore, it makes sense to focus on the specific needs (SEN) of each individual learner. This was the way how were our guidelines formulated. For clarity, the special needs will be divided into 4 groups:

1. Students with specific learning difficulties.
2. Students with SEN in the field of visual perception.
3. Students with SEN in the field of auditory perception.
4. Students with SEN in the motor and/or locomotor domain.

When using the ARphymedes Plus materials, at the bottom of each table students will find a particularly helpful section.

Students with specific learning difficulties

Students with specific learning difficulties have significant difficulties in academic skills (reading, writing, spelling and/or arithmetic) due to their known or unknown disorders or differences in their central nervous system functioning, despite average or above-average intellectual abilities. Typical difficulties are in the areas of attention, memory, thinking, coordination, communication, social skills and/or emotional maturation. This is a diverse group of problems and associated special needs.

Specific learning difficulties can be divided into (Magajna et al., 2008):

- Specific deficits at the level of auditory-visual processes resulting in reading difficulties (dyslexia), spelling difficulties (dysorthographia) and other language-related learning difficulties (e.g., some forms of specific arithmetic disorders, etc.).
- Specific deficits at the level of visual-motor processes resulting in difficulties in writing (dysgraphia), mathematics (spastic dyscalculia), planning and carrying out practical activities (dyspraxia) and social skills.

They often occur in combination with attention deficit hyperactivity disorder (ADHD).

	Specific deficits at the level of **auditory-visual processes**	Specific deficits at the level of **visual-motor processes**
COMMUNICATION	The speaker should consider: • An overview of the topic to be presented in advance, summarising the learning content. • Short and clear oral instructions in a clear sequence, with the speaker giving only a few instructions at a time and repeating them frequently.	The speaker should consider: • An overview of the topic to be presented in advance (know what to expect), summarising the material. • Clear integration and generalisation of the content; - verbalisation of expectations. • Reinforcing and interpreting non-verbal messages (e.g. pictures, videos) with verbal information. • Direct, unambiguous communication (avoid sarcasm, metaphors). • Checking understanding of multiple-meaning words (e.g. used in everyday life as well as in the subject) and symbols (e.g. symbols for measurement quantities, symbols in formulae). • Warnings against changes (tell the reason, slowly integrate them into the mastered routine - substitute teachers, changes of timetable).

	Specific deficits at the level of **auditory-visual processes**	Specific deficits at the level of **visual-motor processes**
ENVIRONMENT	• Label laboratory cupboards and equipment with key words or pictograms and provide a permanent location. • Maintain a safe environment.	• Label laboratory cupboards and equipment with words and provide a permanent place. • Reduce the amount of visual information (posters, decorations). • Provide sufficient space on the work surface and for movement around the classroom. • Use activity lists and timetables (ensuring predictability). • Ensure a safe environment (especially in case of motor problems, anticipation).
THE LEARNING PROCESS	• We follow a clear structure and present new concepts, ideas, and contents, etc. with plenty of examples. • Clearly articulate the flow of procedures (e.g. written steps and pictograms) and give clear instructions. • Incorporate multisensory teaching: hearing, touch, smell, taste (e.g. school garden, natural environment).	• We follow a clear structure and present new concepts, ideas, and contents, etc. with plenty of examples. • Clearly articulate the process (e.g. written steps) and give clear instructions (e.g. in writing, before the activity starts); • Use a unimodal teaching style (e.g. give a verbal explanation first, followed by a demonstration).

	Specific deficits at the level of **auditory-visual processes**	Specific deficits at the level of **visual-motor processes**
	• Leave information on the board for a longer period of time (a learner with reading and writing difficulties needs more time to write it down). • Use colours, signs, and symbols consistently (e.g., arrows to indicate direction, to mark key information). • Provide a list of key words and concepts specific to our subject.	• Leave the information on the board for a longer period of time (a learner with motor difficulties needs more time to write it down). • Allow extra time to do the practical exercises. • Facilitate learning through models (demonstration of the finished product).
TEACHING TOOLS AND MATERIALS	• We include the use of visual aids, models, and diagrams (models, type maps). • Adapt the structure of the material: clear instructions - avoid complex and long written instructions, break down long instructions into shorter ones (bullet points), colour key parts of instructions. • Adapt the design of the material: non-serif font type, larger font size, clear contrast between font and background, larger line and letter spacing. • Emphasise important information with bold, colour, boxes, arrows. • Avoid tasks that simply	• We make it possible to use pencil grips, three-edged pencils, thicker and softer pens. • Use larger shaped tools and materials (e.g., needles, rulers, scissors, erasers). • Use tools to aid composition in writing (e.g., chequered paper instead of lineless paper makes it easier to do arithmetic, draw graphs). • When designing written materials, pay attention to having enough space for notetaking and filling in. • Reduce the amount of visual information in teaching materials (e.g. decorative images).

	Specific deficits at the level of **auditory-visual processes**	Specific deficits at the level of **visual-motor processes**
	require recall of information (listing facts, formulas, completing) - rather check for understanding and application. • Prepare summaries, copies of materials (do not expect to copy large amounts of text). • Use audio recordings instead of reading the text (e.g., reader, tape recorder)	• Where there is a need to use graphical diagrams, attention is paid to simplicity, step-by-step and clear verbal descriptions.
ADAPTATIONS TO ARPHY+ MATERIAL	When using digital tools, adjustments may make sense for the student: • Adjust the font size. • Adjust the font type (non-serif format). • Increase line spacing and/or letter spacing. • enlarge the cursor (mouse). • Adjust the background colour (in case of a dark background). • Use of increased contrast; use of the reader. It is important that the student chooses the most optimal options from the options offered.	When using digital tools, adjustments may make sense for the student: • Increase line spacing and/or letter spacing. • Enlarge the cursor (mouse). • Focus on listening to and reading subtitles in videos and animations. It is important that the student chooses the most optimal options from the options provided. •

Students with SEN in the area of visual perception

Blind, partially sighted and visually impaired students have reduced visual acuity, a narrowed field of vision or visual impairment. Visual loss affects the acquisition of information and social experience. They need an adapted environment, aids, orientation, and communication techniques. Most people with sight loss have at least some useful visions. Blind people can often also at least distinguish between light and dark.

However, the abilities and needs of individuals vary greatly. When considering the use of adaptations, it is therefore important to consider the abilities of each individual.

COMUNICATION	The speaker should consider: • Speech is clear and distinct, appropriate speed of speech and pauses. • The student is spoken to so that he/she knows we are in the room (we say who has come/left). • Describe what is happening, explain the silence ('I am looking for a recording', 'I am waiting for your answer'...). • Call the student by name (not "you"). • When we speak, we are facing the student.
ENVIRONMENT	• Make sure the room is well lit. • Ensure optimal seating arrangements (front - close to the teacher, standing place). • Ensure a clean and dry blackboard, a large enough blackboard image, use of chalkboard colours with strong contrast (and, if necessary, allowances for copying from the blackboard). • Provide a permanent place for repeatedly used tools and equipment (e.g., drawer, cupboard). • Sufficient space on the desk for all aids. • A safe environment.
THE LEARNING PROCESS	• We give precise and rich verbal descriptions of everything we do or important things that happen (experiment, result); • Demonstrate and guide with hands and fingers (tactile demonstration, model, object, etc.). • Allow for longer observation time, task performance, skill acquisition. • Take into account the psychophysical and perceptual capacities in case of fatigue, what is the threshold of

	perception, quality of visual perception ...; • Encourage the student's independence.
TEACHING TOOLS AND MATERIALS	• We follow the principle from the concrete to the abstract (hands-on experience, 3D models, mock-up, 2D tactile image, graphical representation). • We pay attention to clarity when observing objects (monochrome background, colour contrast, adequate proximity, sufficient time). • Incorporate multisensory learning: hearing, touch, smell, taste (school garden, natural environment, models, tactile maps, models, sound recordings, etc.) • Offer personalised learning aids (pens that leave a thick trace, magnifying glass, electronic magnifier, voice recorder). • Offer personalised materials (enlarged print, non-glare background, tactile display, learning content in audio format, braille).
ADAPTATIONS TO ARPHY+ MATERIAL	When using digital tools, adjustments may be reasonable for the student: • Adjust the font size. • Increase line spacing and/or letter spacing. • Enlarge the cursor (mouse). • Adjust the background colour (dark background). • Use of increased contrast. • Use of the reader. • It is important that the learner chooses the most optimal options from the options offered.

Students with SEN in the area of auditory perception

Students with auditory perception difficulties tend to lag their peers in language perception, language production and speech, and these difficulties can also affect various other areas of life, such as communication, education, and socialisation. Deaf and hard of hearing individuals use speech or sign language to communicate. Speech-language and communication skills are significantly influenced by the type and degree of hearing loss, the time of onset – pre-lingual or post-lingual, appropriate, and early habilitation or rehabilitation, cognitive, personality and other characteristics.

When identifying difficulties and associated special needs, it is important to recognise that there are significant individual differences between people.

COMUNICATION	The speaker should be: • Facing the student. • Mostly static (not wandering around the classroom). • Face should be adequately illuminated. • Not covering his/her mouth while speaking, not turning away. • Before taking the floor, the speaker should raise his/her hand for a few moments (or show another visible sign). • Quieten the class before starting (use the agreed sign when the agreed volume is exceeded). The speaker should consider: • Normal rhythm, pace, volume of speech (slow down a little if necessary). • Use of short sentences instead of just listing words. • Paraphrase or summarise the point (in other words, explain the point) if necessary. • Give more time to the conversation and to oral responses, if necessary. • When looking at a model, object, picture, etc., the student cannot listen to the explanation at the same time (especially if he/she is lip-reading or communicating in sign language).
ENVIRONMENT	• Make sure the classroom is well lit (communication with the teacher, lip reading). • Reduce noise in the classroom, acoustic adaptation of classrooms. • Ensure appropriate seating arrangements (front or centre of the semicircle, away from noise sources, etc.). • Safety concerns.

THE LEARNING PROCESS	• We link abstract explanations and concepts to the student's concrete experience and summarise what has been learned. • Provide extended time for learning and review, where appropriate.
TEACHING TOOLS AND MATERIALS	• We create detailed verbal descriptions in advance for the auditory information (explanation of unfamiliar words, instructions, key words, subtitles for videos, summaries using familiar words). • We emphasise multisensory and experiential learning, practical work (demonstration, experiment, project work, etc.). • Facilitate the use of adapted hardware, software, and hearing aids (e.g. hearing aid, FM system, inductive loop).
ADAPTATIONS TO ARPHY+ MATERIAL	When using digital tools, adjustments may make sense for the student: • Guidance on reading subtitles in videos and animations. • Using a pen to highlight important parts or to take notes. It is important that the student chooses the most optimal options from those offered.

Students with motor and/or mobility disabilities

Students with SEN in the motor and/or mobility areas have congenital or acquired impairments of the locomotor system, central or peripheral nervous system. As a result, they may have difficulties in participating in activities and interest.

The difficulties may relate to the ability to move independently, balance, coordinate, perceive and sense stimuli from the environment. The difficulties and associated SEN may manifest themselves in different ways for different individuals. A student may have a severe motor disability and need assistance with movement, or there may be milder difficulties in handling smaller objects. Associated conditions (e.g., long-term conditions) are often present and it is important to be familiar with their characteristics and management.

Therefore, students need certain adaptations to the programme and aids *(e.g. chair, desk, adapted pens, tools, ICT)*.

COMUNICATION	*There are no specifics.*
ENVIRONMENT	• The classroom and laboratory should be well organised (enough space between tables for wheelchair access, free movement). • Adapted work surface (e.g. adjustable height and slope). • Ensure smooth access to all classroom facilities even from a seated position (e.g. optimum height, flexible connections to water, gas, electricity. • Positioning so that the student has an unobstructed view of the teacher's demonstrations. • Mirror above the teacher demonstrating the procedure (if necessary to view the demonstration uninterrupted). • Ensure safety.
THE LEARNING PROCESS	• Allow more time to complete the task. • The student should not be excluded from the activity (adapt if necessary). • Design the timetable thoughtfully (e.g. moving between floors). • Agree with the student how much help and what kind of help he/she needs to get him/her used to being independent.
TEACHING TOOLS AND MATERIALS	• Provide a non-slip work surface or tray (e.g. non-slip foil). • Use support stands, clamps for objects (e.g. beakers, test tubes). • Use handles on some equipment (e.g. beakers). • Use surgical gloves for handling wet, slippery objects. • Adapt the procedure to use larger masses, volumes if necessary. • Offer pen tips for easier grip, if necessary. • Enlarge the format of the worksheets, leaving more space for writing down answers. • Allow the use of adapted hardware and software (e.g. adapted keyboard, mouse, etc.).

ADAPTATIONS TO ARPHY+ MATERIAL	When using digital tools, adjustments may make sense for the student: • Adjust the font size. • Increase line spacing and/or letter spacing. • Enlarge the cursor (mouse). • Viewing a video instead of doing an experiment. It is important that the student chooses the options that are the most optimal for him/her.

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Teachers' notes

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Teachers' notes

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