PHYWE

'Take It Slowly...' –How to Shoot and Analyse High-Speed Videos

A Concise Student's Manual

Measure dynamics PHYWE

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Contents

The Camera: Casio EX FS10

This camera is a sensitive measuring device. During your school career, you will get to know quite a lot of different measuring devices for all kinds of tasks. Please handle all these sensitive devices with care.

If a memory card with sufficient storage capacity and a fully charged battery are already installed in the camera, you can skip straight to the Chapter "**Camera**" on Page 4.

Preparing the Camera

Before you can actually start shooting, you need to prepare the camera for the jobs you want it to perform. The camera needs a power supply, so you should charge the battery if you don't want the camera to run out of juice right in the middle of shooting.

Removing and charging the battery

Image 1: How to open the camera base and remove the battery.

Hold the camera as shown in Image 1. On the right side, you see a plastic cover with a small black switch (Image 1). It will be in position "LOCK". To open, move the switch to the left to position "OPEN" to release the cover. You can now see two slots. In the upper slot, you find the battery. It is secured with a small notch on the right. In the smaller slot below, the memory card is installed. To remove the battery, push down the notch, and the battery is ejected (Image 2). Then, place the battery in the charger provided.

Image 2: How to insert the battery in the charger provided.

Important: do not leave the camera base cover open, because it snaps off easily. Close the cover by flipping the switch on the cover from "open" back to the "lock" position (Image 3).

Important: a red light on the charger indicates that the battery is still charging. When the battery is fully charged, the red light is off. It takes about 90 minutes to fully charge the battery.

Re-inserting the battery

Once the battery is charged, place it back in the camera (Image 3). Hold the camera in the same position as before and turn the battery so that you can see the captions "Casio" and "Exilim". There are also arrows printed on the battery showing you the correct way to insert it.

Image 3: Correct insertion of camera battery, closing the camera base cover.

Important: The camera is a highly sensitive device. Insertion of battery or memory card into the camera must work smoothly and without any force. If you have any problems at first, try going through the steps again one by one.

Inserting and removing the memory card

This camera stores images and videos on **SD memory cards**. The slot for the card is in the base of the camera, directly underneath the battery slot. To insert the memory card, open the camera base cover the same way as for inserting the battery (Image 1). You can see a narrow slot underneath the battery. Hold your memory card so you can see the writing on it. The gold-coloured contacts are now facing down and the 'cut-off' edge is facing forward. You can now push the card into the camera slot. To remove the card, press on it gently, it will pop out a little towards you, and you can pull it out easily.

Image 4: How to insert the memory card.

Important: Make sure you have enough memory available on the card you are using. You should have at least 300 MB free memory.

Important: When you have switched on the camera[1] and the caption "The card is locked" appears on the camera display, you need to remove the card and re-insert it. Now the camera can store your videos on the card.

Camera Settings

Once the charged battery and the memory card are inserted, you can switch on the camera. The 'ON/OFF' button is on the top of the camera in a small recess.

[1] Find out how to switch on the camera on the next page.

Image 5: The camera as seen from the top. The 'ON/OFF' button is in the centre.

When you press the "Menu" button, then in the top line of the display, you see the captions "REC", "Quality" and "Set Up" (one of the captions is highlighted in red). Underneath, you see a list with the available setting options. By pressing the control keys (on the control ring) left or right, you can move the red highlighting to a different caption and its setting options. Select the caption "Quality". In the list displayed, you see various symbols, with "Quality" next to them. The second symbol represents a video camera. Here, you can set the video quality. If your task is to record normal videos, set the quality "STD" (short for Standard). If you want to shoot in high-speed, look at line 3. Here, you see "HS" before the video camera, which is, of course, short for high-speed. Select the frame rate "210 fps" and press "SET" (in the control ring). This also closes the menu, and you see the live image once again in the camera display.

Setting for normal videos

To record normal videos with the camera, switch the lever on the far right at the back of the camera down to the camera symbol. Afterwards, under the menu item "Quality", select the film quality "normal".

Important: Even if you find it tempting, the setting "HD" (high-definition, i.e. high image quality) is actually not at all helpful in video analysis. The reason is that for normal videos, the camera shoots 30 frames per second, while for high-definition, 30 "half-frames"[2] are recorded.

Setting for high-speed videos[3]

To produce high-speed recordings with the camera, you need to switch the lever on the far right at the back of the camera upward. Then, in the menu under "Quality", you select the HS frame rate "210 fps".

Important: A setting of 210 fps is fine for any high-speed recording. If you select a higher frame rate (420 fps or 1 000 fps), the recording area is reduced, the image is grainier and the recording is darker or completely black!

Important: For shooting, make sure there is enough light. Sunlight or (conventional) light bulbs are best for lighting the experiment. Energy-saving light bulbs, LEDs or fluorescent lamps are less suitable.

Recording the videos

At the back of the camera, top right position, you find a button with a red dot. Press this button, and the recording starts; press it again to stop recording.

[2] Half-frames are images where only every second line is recorded. The missing lines are calculated afterwards. The reason for this recording mode is that for full frames, the number of image dots (pixels) in the image and therefore the data volume is much higher.

[3] Shooting videos with more than 30 frames per second is called **high-speed recording**. For example, if you record a video at 300 **fps** (frames per second) and play it back at 30 fps, you see the video in tenfold slow motion.

Playing back the video

Above the control ring, you find two buttons. You see a "play" symbol on the left one; press it to watch the photos and videos you have shot. To start a video, press the "SET" button in the control ring.

Closing the camera menu

At the back of the camera, you see a button with a photo camera symbol. Press this button to close any open menu and to return to the camera's live image display.

A Falling Metal Ball as an Example of High-Speed Recording

Setting up the experiment

Once you have made yourself a little familiar with the camera, start setting up the experiment. What you will need is:

- A small, dark-coloured metal ball
- A large, hard surface (school desk)
- A measuring stick with holder

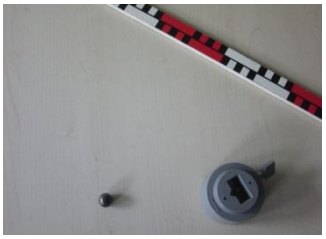


Image 6: Materials required for the experiment.

Place the measuring stick in the holder horizontally (Image 7). Hold the ball in the open palm of your right hand and position your hand 50 cm above the surface. With your left hand, give the ball a push to make it roll off the palm, making sure the falling ball is well visible (not directly in front of the measuring stick). You can see the ball fall and bounce up again. After the first impact, does the ball bounce back up to a height of 50 cm? How far does the ball bounce? Does it bounce back the same distance after each impact? Does the ball change its shape on impact?

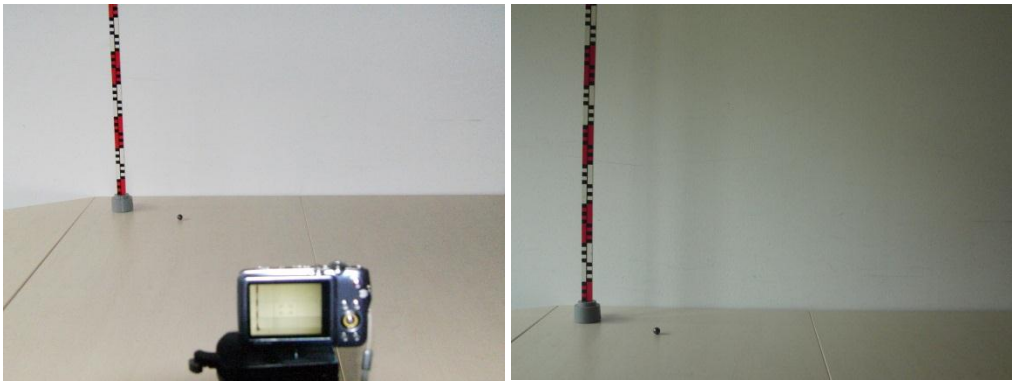


Image 7: Setup of the experiment and camera view.

If you carry out the experiment by yourself, you will hardly be able to see any of that. Even if your classmate is watching, he/she will have problems determining anything. The experiment takes place too quickly. And this is where the high-speed camera comes in handy. But for the video to be of any use, you need to pay attention to a few things:

1. **Background:** make sure you have a uniform background without any structures and only one colour (preferably light grey). The colour of the object you want to film should be in clear contrast to the background. **Suitable backgrounds** are
    - Smooth walls / wallpaper
    - Clean school whiteboards

- Smooth, creaseless fabrics in one colour (e.g. curtains)

Unsuitable backgrounds are, for example:

- Wood-chip wallpaper, structured or patterned wallpaper
- Badly wiped whiteboards or whiteboards with writing on them
- Colourful or creased fabrics

2. **Experiment setup:** Set up the experiment close to the background you are using. In the photos in Image 7, the measuring stick is positioned about 15 cm from the wall.
3. **Camera position:** Place the camera in a straight and stable position at a distance of approx. 2 m to the wall. The best way is to use a tripod for the camera. At the base of the camera, you find a screw thread to the left of the cover for battery and memory card. You can fasten the screw of the tripod there. In the example in the photo, the camera is positioned 2 m from the background, on a tripod.
4. **Camera view:** Position the camera so that the entire experiment can be viewed. Change the height of the camera so that it is positioned more or less at the centre of the entire experiment. Find the "zoom" button at the top of the camera. By zooming in or out, adapt the image section and check that all the necessary objects can be seen in the display. Remember that the actual image section will be smaller! Do a trial shot and adapt the image section on the camera display if necessary. The measuring stick should be clearly visible in the video (Image 7)!
5. **Light and shadow:** If possible, use indirect daylight for your shoot. Make sure your own shadow is not on the experiment. If there is not enough light, you can use an overhead projector, a desk lamp or a construction lamp for lighting. If you set up your experiment so that there is light from **both** the **left** and the **right**, the metal ball will not cast any shadow. This will later make analysis easier. Take care: the lamps get very hot!
6. **Recording the experiment:** The best way to work is with a partner. One of you handles the camera; the other lets the ball roll off his or her palm. Start recording just before releasing the ball. It takes a short moment before the camera starts recording. End the recording by pressing the record button when the ball is no longer visible in the display or when it has stopped moving about.

Editing Videos on a Computer

Transferring your video to the computer

Now that you have finished with the experiment, you need to transfer your data to a computer. First, switch on the computer. Create a new folder/directory on the desktop. As a folder name, preferably use your surname and first name as well as your form/class (example: "SabineMeyerClass5c"). Now, you want to transfer your data from the camera to the computer. You can do this in two ways:

1. Connect the camera to the computer with the USB cable provided. You can see in Image 8 how to connect the cable. When the markers ▶ on the camera and ◀ on the plug of the USB cable are pointing at one another, the plug should fit. Connect the camera and the computer like this with the cable. Once the camera is connected, switch it on.

Image 8: How to connect the camera to a computer with the USB cable provided.

2. You can also take out the memory card and insert it into the SD card slot of the computer, if the computer you are using has an SD card slot.

When you have connected camera and computer (or inserted the memory card in the computer slot), a window opens automatically. Select "Open folder to view files". A further window opens displaying the folder/directory "DCIM", which is the folder/directory you need to open.

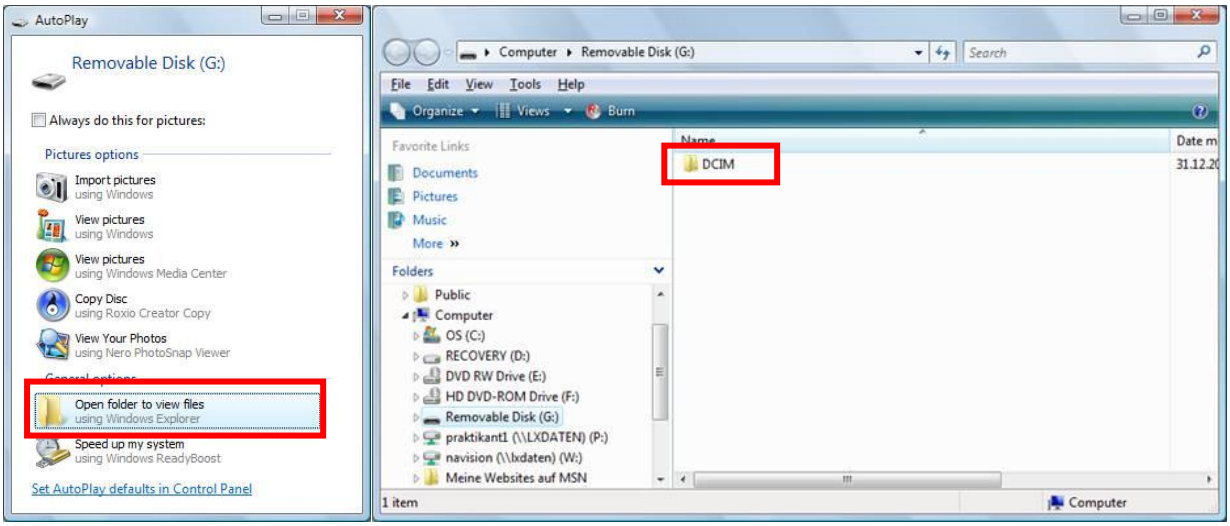


Image 9: Windows which open during data transfer.

A further folder/directory appears named "100CASIO". Open that one, and you can access the data. Select the newest video and copy it to the folder/directory you have created on the computer **immediately**. Depending on the length of the recording, this may take a few minutes.

Opening the video in measure dynamics

Once the video has been transferred from camera to computer, you can open and edit it using the program "measure dynamics". When you have started "measure dynamics", click on "Open video …", then click on "Look in" and select "Desktop". Then scroll down until you can see your folder/directory. Open your folder/directory and select your video. You can now see the video image appear in the right-hand window.

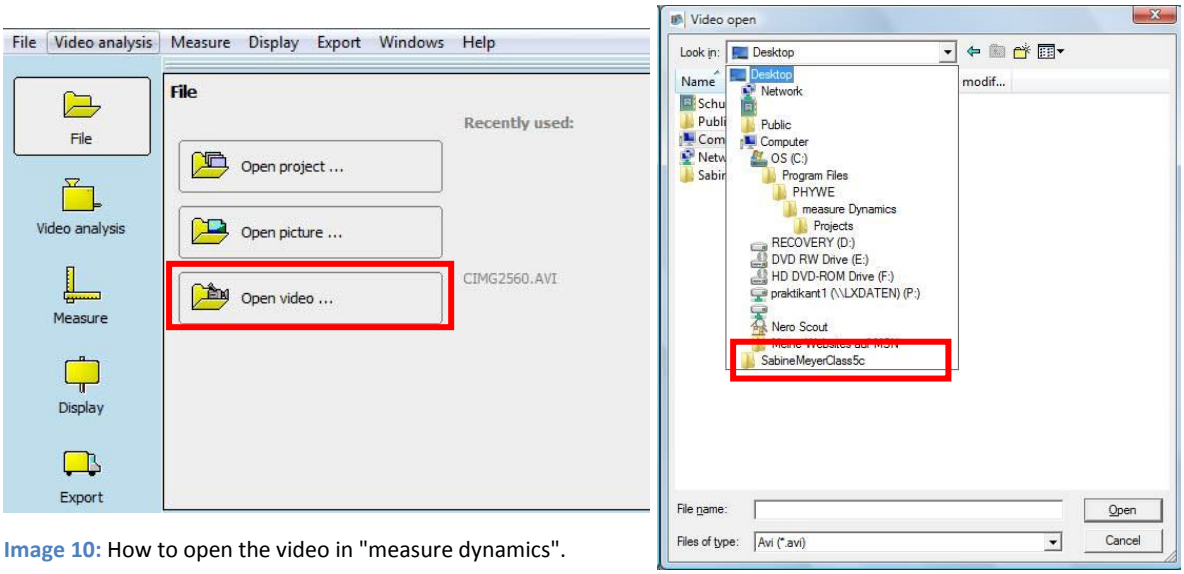


Image 10: How to open the video in "measure dynamics".

Viewing the video in measure dynamics

You can now view the video. In Image 11, you can see the control field for the video. The button starts the video. To stop the video, click the same button again. With , you can skip to the beginning or the end of the video. Use to move forward or back by only one image (frame). With , you can select a new start or end. To run the video in reverse, click on . You can change the size of the video image by clicking on . With , you can let the video run faster or slower. If you want to omit certain images (frames) when analysing the video, you can modify the **Framestep** with .

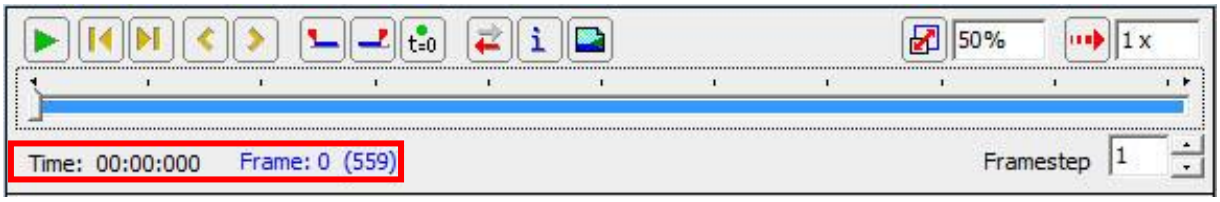


Image 11: **Video control field** in measure dynamics with menu field, time and frame index.

Editing the video

In your video, it takes a while until the ball begins to roll and can be seen properly in the recording. A good while before the video ends, the ball also disappears from view. You should cut out these parts of the film in measure dynamics by selecting the suitable starting and ending point with .

Analysing the Video Automatically

Scaling the video

Once you have selected the frame rate as well as the beginning and end of the video, you can start with the actual video analysis. Begin by selecting the menu item "Video analysis", then click on "Scaling" (see Image 12).

Important: Usually, a hint window pops up where the individual steps are explained.

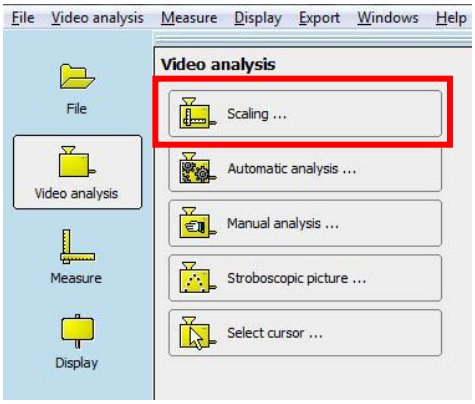


Image 12: Menu view "Video analysis".

In the menu item "**Scaling** ...", you can select either “Change

frame rate", "Origin and Direction" or "**Calibration**". Select the item "Calibration". You see an image as shown in Image 13. In the video image, in the top left corner, two green dots with a connection appear (in the right-hand red box in Image 13). Drag the dots onto the scale so that you can read the distance between the two dots. Enter that distance next to "Type length and unit of selected distance". By clicking on the green check mark, the scaling is set. Now click on the "Close" button (bottom left in Image 13). This is how easily you can scale your video.

In the example, a school ruler is used. The white and red sections have a length of 10 cm (0,1 m). If you select the dots and the distance as shown in Image 14 (Page 10), you have to enter 0.5 m as the distance.

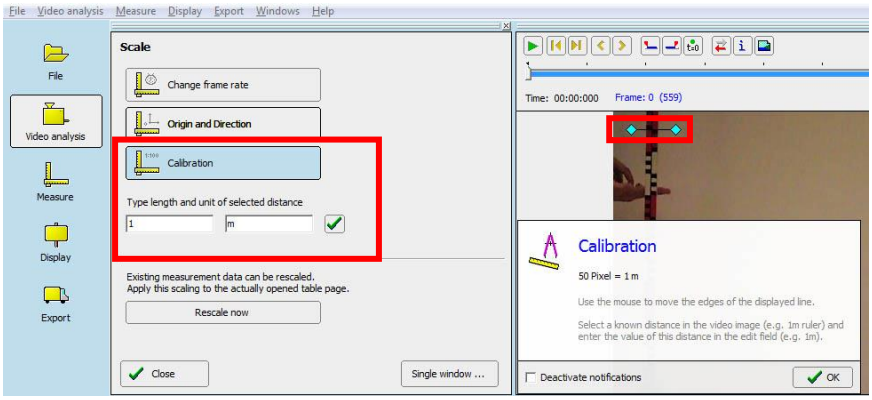


Image 13: How to set the length (scaling). In the hint window, the work steps are displayed.

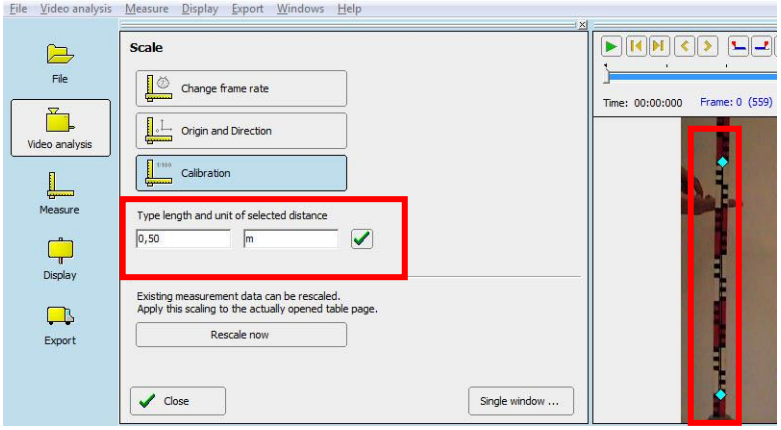


Image 14: Example of scaling: 5 red and white sections = 50 cm = 0.5 m.

Selecting the frame rate in measure dynamics

The high-speed videos are played back in **slow motion**, which means slower than the movement actually happened. The advantage is that you can see the experiment slowed down. Unfortunately, the time distance between the individual images in the video is no longer accurate, so calculations will be wrong. In the menu item "Scaling", you can **change the image rate (frame rate)**. To do this, click on "Scaling…", then on the button "Change frame rate". You will now see the display as in Image 15. Tick the box next to "Change frame rate now" and enter "210" in the field at the bottom. This is the frame rate you recorded the experiment with. Click on the green check mark to set these changes!

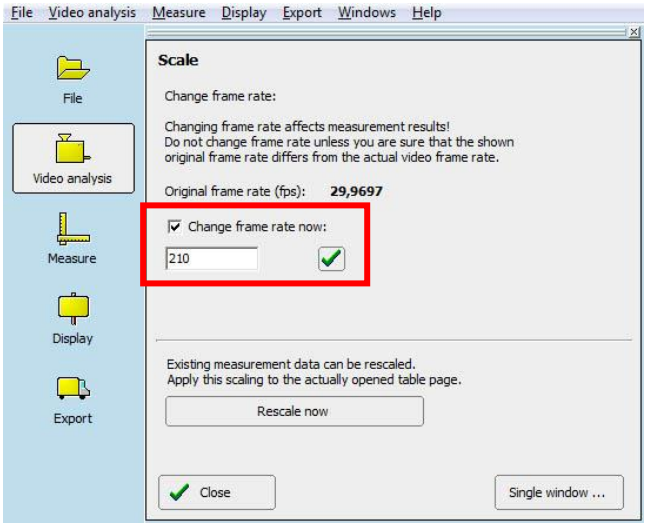


Image 15: How to change the frame rate in measure dynamics.

Analysis of the video

When you have scaled the video and clicked on "Close", you automatically get back to the "video analysis" menu. This time, select the item "**Automatic analysis** …", directly under the item "Scaling". You will see a display resembling Image 16. First, select a **frame (video image)** in which your object (here: the metal ball) can be seen well. Then place the cursor[4] in the centre of the object and click. If you see a green box now, the computer has clearly identified the object. Additionally, a hint window pops up displaying "Object found", as in Image 16. In the hint window, click on "OK" and then on "Start" to run the analysis.

If the box is yellow, identification did not work so well. In many cases, the analysis still works. If the box is red or the analysis fails to work well, select a different spot in the video, mark your object there and run the analysis again.

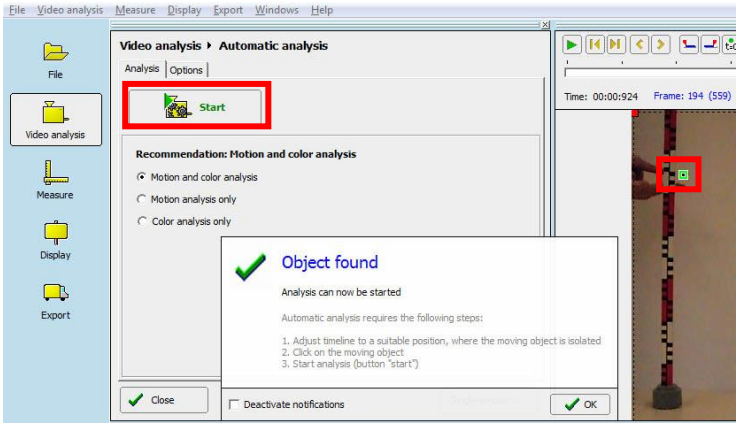


Image 16: Menu "video analysis", Selection "Automatic analysis". Click with the cursor on the object, and then start the analysis.

Image 17 is a screen shot of a video analysis. The purple frame should always remain on the object.

[4] The **cursor** is the mouse pointer.

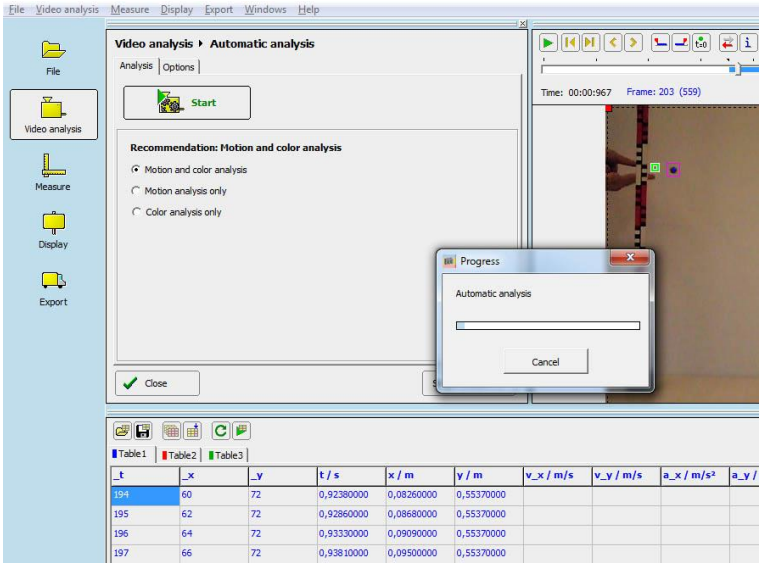
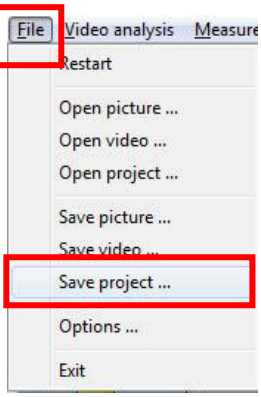


Image 17: Screen shot of a running video analysis.

Saving your Project

The computer has now already analysed your video. Before you continue, you should **save your project**. To do so, select "File" on the top left, then "Save project …". Your project does not have a name yet. Select a name which gives you the key information, for example: "ProjectMetalBallSabineMeyer5c".



Opening your Project

If you want to continue with this project at a later time, open your folder/directory on the desktop and click on the file with the extension ".prj". In this example, you would open the folder/directory "SabineMeyerClas5c" on the desktop. There, you would find the file "ProjectMetalBallSabineMeyer5c.prj". If you open this file, measure dynamics should start automatically. If not, click on the file with the right mouse button, and in the list displayed under "Open with", select the program "measure dynamics".

Working With the Analysis Results

Position or x-y diagram

If you want to observe how the ball bounced around the image, you can take a look at a position diagram (also called x-y diagram). To do so, in the menu bar on the left, click on "Display", then select "**Diagram** …". Under "**Extra diagram** …", the diagram opens in a separate window, and you can look at several diagrams next to one another at once.

Open a diagram and double-click on the diagram with the left mouse button. Now a window opens in which you can **change the settings in the diagram**. First, for the "Horizontal axis", select "x / m" instead of "t / s", then click on 

, and

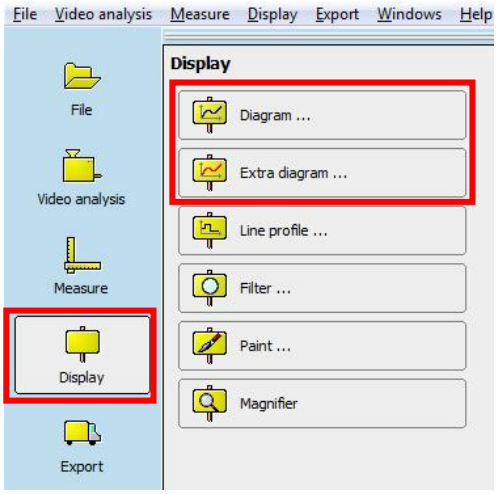


Image 18: How to open the diagram.

then on  , so that the horizontal axis displays the "x / m" values. Click on "OK" to save the changes.

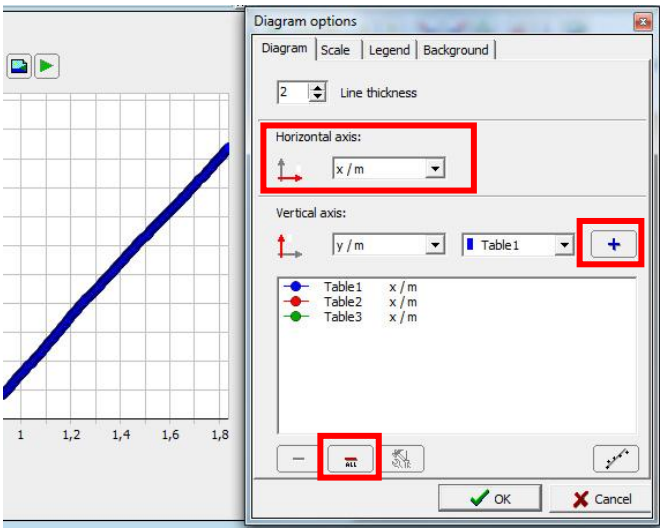
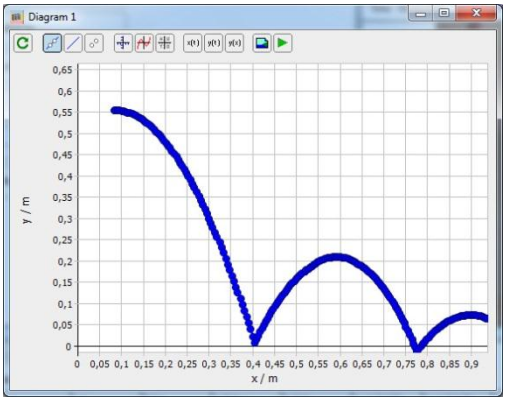


Image 19: How to change the diagram.

If you did everything right, you should now see a diagram resembling this one:



What you have here is a so-called "x-y diagram" or "position diagram". At the top of the diagram, you see different buttons. The button on the far right looks like the "play' button in the video window. Why don't you try out what happens if you click on it? Did you notice that the diagram displays the course the ball took?

Other diagrams

You can create different kinds of diagrams if, as in Image 19, you select different settings for the horizontal or vertical axis. If you want to know how quickly the ball moves to the right, select "t / s" for the horizontal axis and "v_x / m" for the vertical axis. How does vertical speed change over time, i.e. the speed in direction y (horizontal axis: "s / t"; vertical axis: "v_y / m")? Can you see how the speed changes?

Direction arrows of movement on the object

There is a way to display in the video how fast and in which direction the object is moving at each moment, i.e. in each video frame. The arrow is a so-called **filter**. You find this filter under "Display" (on the left in Image 20). Two filters are already in the list, and filter 2 can be seen. You can recognize this because the box on the left next to "filter 2" is ticked. If a box is empty, the respective filter is deactivated.

To have the velocity arrow displayed in the video, click on "New". The "Selection" window opens, and there, you select by clicking[5] "Velocity arrow" and closing the window with "OK".

[5] Double-click on "Velocity arrow", and the filter is selected and the window closes.

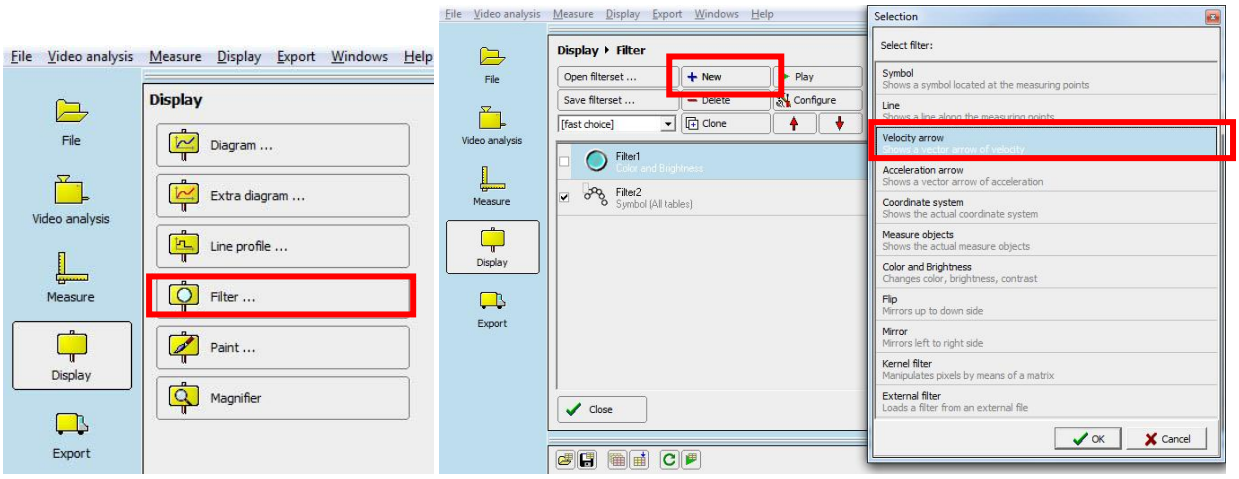


Image 20: How to display velocity arrows: In the submenu "Filter", click on "New" (red box) and in the window "Selection", select "Velocity arrow" (red box), then click on "OK".

With the button "Play" to the right of the "New" button, you can check if the velocity arrow is displayed. Do you notice something when you look at the velocity arrow?

Stroboscopic image

Apart from the x-y diagram and the arrows, there is another way of showing the movement of the ball in a picture: the **stroboscopic image**. In the menu "Video analysis", select the item "Stroboscopic picture …". Click on "Start", and after a few moments, you get a stroboscopic image of the experiment. Click on "Keep this picture …" to save the image. A new window opens containing this image. Then click on to save the image. Once more, choose an obvious name, such as "StroboSabineMeyerClass5c".

Index