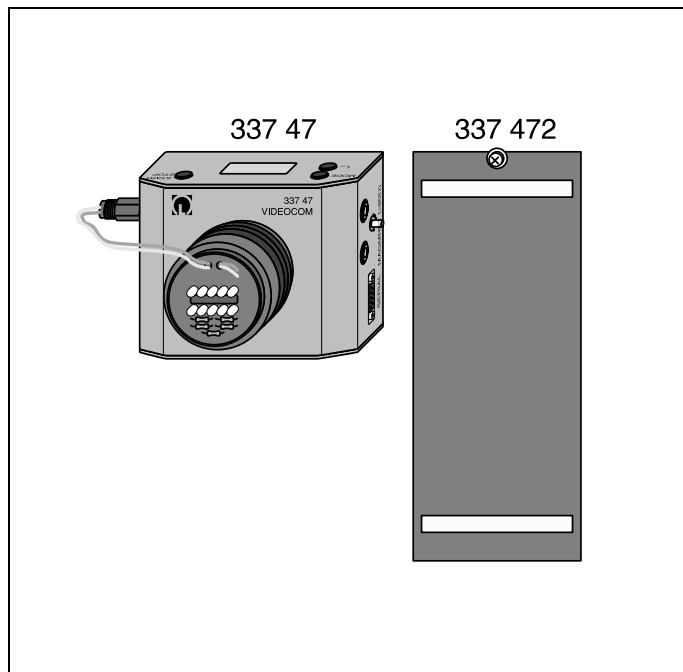


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Instruction sheet

337 47

337 471

337 472

VideoCom Retroreflecting Foil Falling Body for VideoCom

Fig. 1

VideoCom (337 47) is a camera designed for connection to the serial interface of a computer. Using a single-line CCD (charge-coupled device), it registers information which can be processed and evaluated on the computer using the enclosed software. This device enables high-resolution, contact-free recording of linear motions as well as relative intensity measurements.

The falling body for VideoCom (337 472) is ideal for determining the gravitational acceleration g .

Experiment examples:

- uniform and accelerated motion on a track (e.g. Newton's equation of motion, Newton's definition)
- bar pendulum (including multiple coupled pendulums)
- collision experiments (including confirmation of Newton's third law, action = reaction)
- free fall
- diffraction at a slit, multiple slit and grating
- diffraction at a half-plane (edge)
- filter transmission curves

Note:

To get the most out of VideoCom, you need to become familiar with the software and how to use it properly. To assist you in this, the software is provided with a comprehensive help function (context sensitive and searchable). Please take the time to read these help texts carefully, and print them out if necessary.

1 Safety notes

- Use only a plug-in supply unit 12 V AC with cannon plug (e.g. 562 791) for the voltage supply.
- The camera will not function properly in backlighting or out of doors.
- Keep the camera lens and CCD clean.
Clean the CCD using only a cotton cloth soaked in alcohol.
- Store the retroreflecting foil in a cool, dry place, and do not scratch it.
Clean the foil using only warm water with a little household dish soap; use a soft cloth.
- Drop the falling body only on shock-absorbing surfaces.

• Electromagnetic compatibility

The European directives on electromagnetic compatibility (EMC) require that the manufacturers of electronic equipment notify the operators of such equipment of the following potential interference effects. The interference effects described below may occur, but are not inevitable. Actual interference is extremely improbable.

The electromagnetic radiation emitted by VideoCom exceeds the cutoff values specified for class B of the standard EN 50 081-1 resp. EN 55 022 (household standard). The device corresponds to limit class A (industrial standard); its unrestricted operation is thus only permissible outside of residential areas. If electromagnetic interference should occur in neighboring residential areas in spite of restriction of the use of this device to the designated teaching room of the educational facility, the operator may be required to implement suitable measures to eliminate this interference and to bear all costs of such measures.

2 Description, technical data, scope of supply

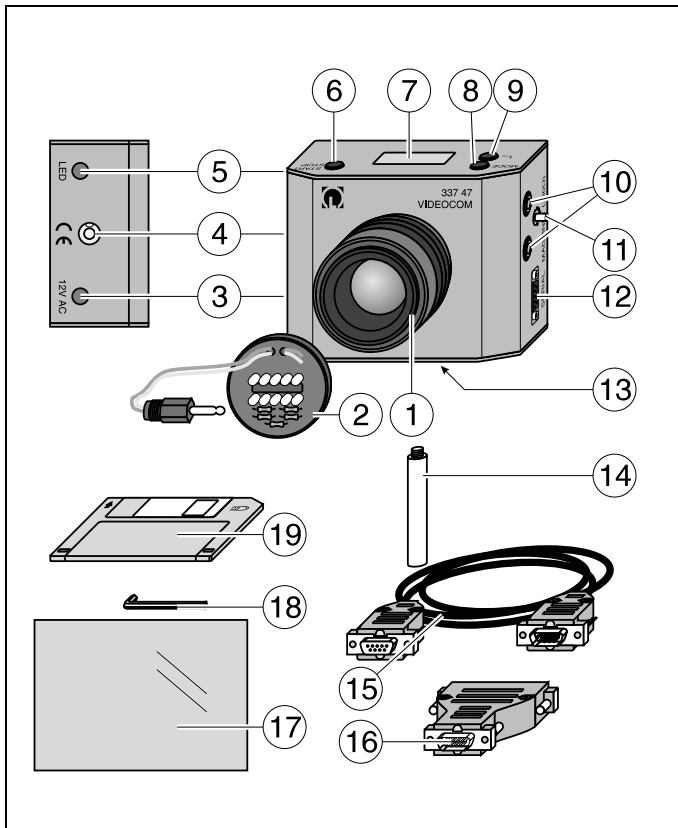


Fig. 2
VideoCom (337 47)

2.1 VideoCom (337 47), see Fig. 2

- ① 50 mm lens, attached via hex screw on housing
- ② LED flash, for screwing onto lens (adjustable frequency and intensity); connected to jack ⑤
- ③ Connection socket for supply voltage (12 V AC) from plug-in power supply with cannon plug (e.g. 562 791)
- ④ Spirit level for vertical alignment of VideoCom (e.g. for determination of gravitational constant using the falling body (337 472))
- ⑤ Jack for connecting LED flash ②
- ⑥ START/STOP key for starting and stopping the measurement (also possible remote-controlled via computer)
- ⑦ LC display to show settings and adjustment aid
- ⑧ MODE key for selecting the time interval and switching between position and intensity measurement (also possible remote-controlled via computer)
- ⑨ t_{LED} key for manually adjusting intensity of flash (also possible remote-controlled via computer)
- ⑩ Pair of 4-mm safety sockets for connecting a holding magnet
- ⑪ Adjusting pin for setting the voltage at ⑩ up to approx. 16 V
- ⑫ 9-pin serial interface for connecting a computer using the enclosed cable ⑮
- ⑬ Standard camera thread

Included in scope of supply:

- ⑭ Stand rod (107 mm long) with standard camera thread
- ⑮ Serial cable, 9-pin
- ⑯ PC adapter (9 to 25 pins)
- ⑰ Retroreflecting foil, self-adhesive, on A5 sheet
- ⑱ Allan wrench (dia. 1.5 mm) for mounting screws of lens ①
- ⑲ Disk with VideoCom software for Windows 95 and Windows NT

Measuring principle

To record motions, a strip of retroreflecting foil is attached to one or more bodies (replacement foil 337 471). VideoCom recognizes the reflections of the LED flashes at the foil and assigns these to the actual positions of the bodies. By repeating these at regular intervals, VideoCom enables you to realize numerous experiments on linear motions using existing equipment (e.g. track, pendulums).

For relative intensity measurements, VideoCom converts the intensity distribution into the relative brightness values, each with 8-bit resolution.

Measuring and evaluation are conducted using the enclosed software with integrated help functions.

Technical data

Light-sensitive pixels:	2048
Focal length of lens:	50 mm
Exposure time:	1/800 s (constant)
Flash duration:	1/8000 s to 1/800 s (automatic and manually adjustable)
Max. permissible background intensity for path measurements:	approx. 10 % (path measurement is thus not possible for backlighting or outdoors)
Path resolution:	about 1/4000 (corresponds to 0.25 mm for 1 m observable path length resp. at approx. 2 m distance)
Max. observable path length:	typically approx. 2.5 m (much greater lengths possible for darkened backgrounds when lens aperture is opened)
No. of simultaneously observable bodies:	max. 10
Maximum time resolution:	80 pictures per second (for no more than two bodies registered)
Scattering in intensity measurements:	less than ± 1 %
Holding-magnet voltage:	adjustable up to about 16 V and switchable via program control; required resistance of magnet $\geq 80 \Omega$, overload-protected
Computer connection:	serial interface (sub-D 9)
Electrical connection:	12 V AC
Dimensions WxHxD	approx. 130 mm x 105 mm x 110 mm (with lens)
Weight:	approx. 0.6 kg

2.2 Retroreflecting foil (337 471)

The self-adhesive retroreflecting foil reflects incident light precisely into itself (triple-mirror principle). VideoCom distinguishes this reflection from the background by measuring its intensity and uses it to determine the position of the foil (see Fig. 5). The screwed-on LED flash is critical as a light source. The foil reflects the light back to precisely this point.

Dimensions: approx. 150 mm x 210 mm (approx. A5)

2.3 Falling body for VideoCom (337 472), see Fig. 3

- ⑳ 2 strips of retroreflecting foil 200 mm \pm 0.2 mm apart
Note: The two strips make it easier to calibrate the path for a measurement and, if desired, to linearize the optical image on the CCD.
- ㉑ Holder for attaching to holding magnet, e.g. (336 21)

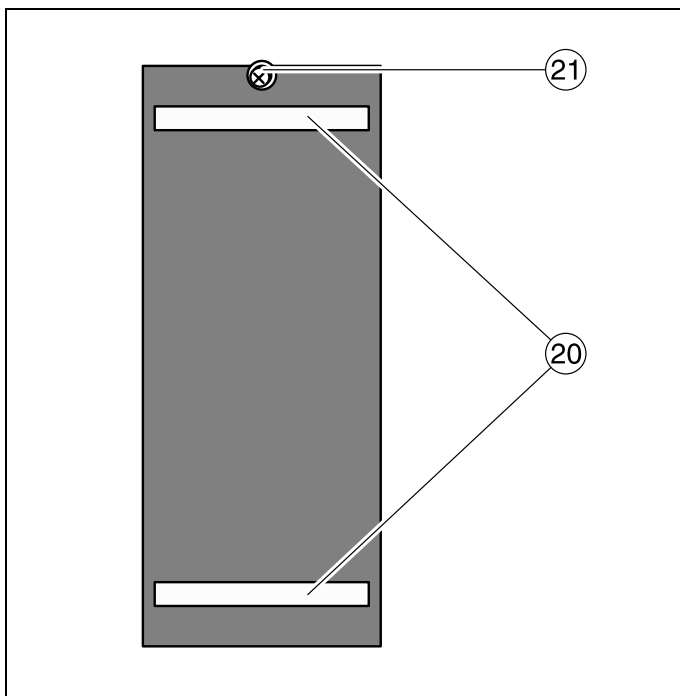


Fig. 3
Falling body for VideoCom (337 472)

3 Operation

3.1 Putting into operation

- Additionally required:
Plug-in power supply 12 V AC with cannon plug (e.g. 562 791)
Camera tripod (e.g. 300 59) for free-standing setup
Holding magnet (336 21 or from 337 50 or 337 30) for synchronizing the start of the motion and the measurement
Computer, min. 486 DX 2/66 with Windows 95 or Windows NT
- Install the software before using the device for the first time (see section 3.4).
- Always use VideoCom together with the flash ② for motion experiments.

- Attach a strip of retroreflecting foil ⑰ to the experiment body for recording motions (see section 3.3).
- Attach VideoCom to the serial interface and put it into operation by connecting it to a power source.
Note: the software issues an error message when VideoCom is not properly connected.
- Configure (section 3.2), adjust and calibrate (section 3.2.1 or 3.2.2) VideoCom, then record and evaluate your measurements.

3.2 VideoCom

VideoCom can operate in one of two main operating modes (motion recording and intensity measurement), each with a variety of functions (various time intervals for recording motions, and a choice of number of pixels when measuring intensities). The current operating mode is always indicated in LC display ⑦. The MODE key ⑧ toggles between operating modes in sequence.

When measuring positions with the LED flash ② attached, the illumination duration of the LEDs is normally automatically controlled, and is indicated in the display ⑦.

You can also set this time manually using key t_{LED} ⑨. The manual setting applies until automatic mode is reactivated using the MODE key ⑧.

The START/STOP key ⑥ controls the recording of measured values in the connected computer; during motion recording, it switches the voltage at the holding-magnet sockets ⑩ off and on.

All of the VideoCom operating functions described above can also be completely controlled via software.

3.2.1 Adjusting VideoCom for recording motions

When motions are to be recorded (see Fig. 4), the camera looks for the reflections of the retroreflecting foil (see also section 3.3). When these are detected, their number, their maximum width in % and their position are displayed in the VideoCom LC display ⑦. The f-stop of the lens should be set to the smallest setting, and the lens focus set to infinity (this is usually sufficient due to the great depth of focus). The following procedure has proven most effective for further adjustment:

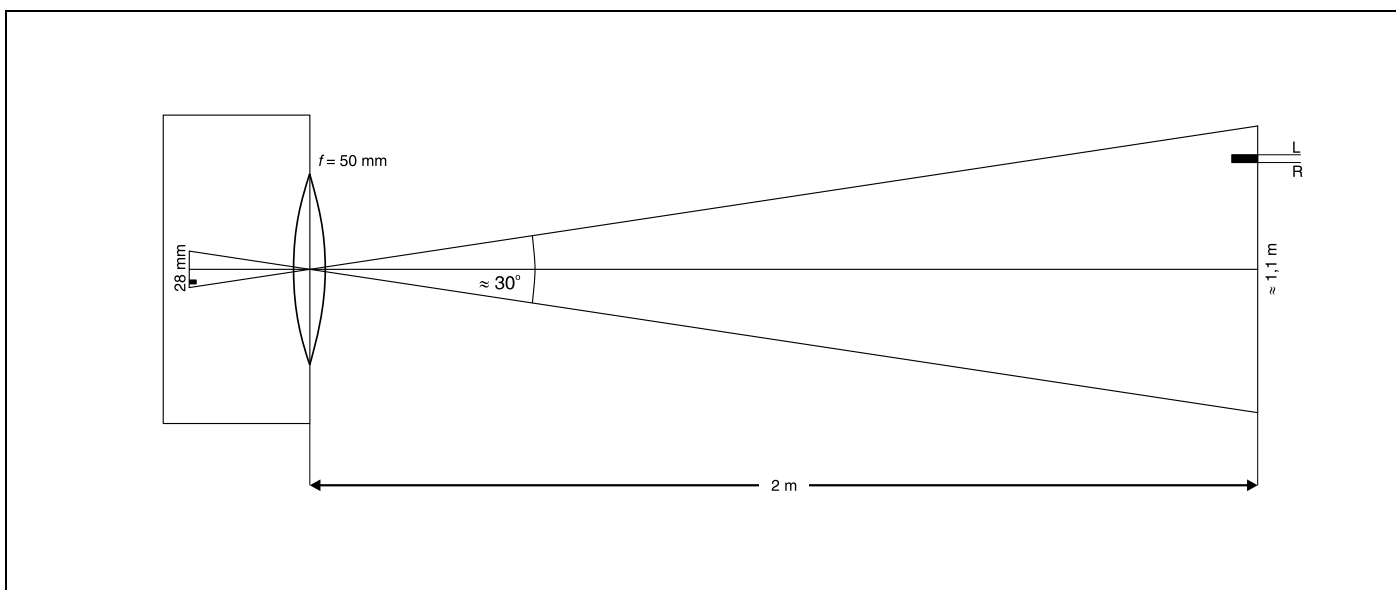


Fig. 4
Optical parameters for VideoCom with a focal length of 50 mm at a distance of 2 m from the moving body.
In this case, the motion can be tracked over a path length of about 1.1 m. The CCD element used here has 2048 pixels. The coordinates for the left edge L and the right edge R of a body are thus between 0 and about 2000. This corresponds to a resolution of around 0.5 mm. The sum $L+R$ between 0 and around 4000 is a measure for the midpoint of the body, so that its position can be resolved to 0.25 mm!

Horizontal motion

- Position one reflection each (a total of two reflections) at the left and right edges of the motion range (if only one reflection is used, you will need to repeat the following steps).
- Set up VideoCom by eye so that it is parallel to the motion.
- Place VideoCom so that its distance is about twice the path length.
- Set the height so that at least one reflection is indicated in display ⑦.
- The second reflection may still lie outside the field of view (increase the distance) or above or below the line of sight (tilt the camera laterally).
- Finally, both reflections should be clearly indicated at the left and right edges of the LC display ⑦ (see Fig. 5), so that even a slight variation of the adjustment cannot affect this.
- Calibrate the pixel spacing by specifying the positions of the two reflections along the path (in the software).

Vertical motion (free fall)

- Suspend the falling body from the holding magnet; using adjusting pin ⑪, set the voltage ⑩ of the holding magnet as low as possible, so that the start of measurement and free fall are virtually simultaneous.
- Align VideoCom vertically (use spirit level ④).
- Place VideoCom so that its distance is about twice the falling height.
- Arrange the setup so that the two reflections are clearly indicated in the upper range of the LC display ⑦, so that even a slight variation of the adjustment cannot affect this.
- Calibrate the pixel spacing by specifying the positions of the two reflections as 0 m and 0.2 m (in the software).

Note

If it is not possible to adjust VideoCom because too few or too many reflections are detected (e.g. due to unfavorable lighting conditions), the software for evaluating motions allows you to display the measured intensities (intensity test). A typical intensity distribution shows a peak of at least 25% amplitude as well as max. 10 % background for each reflection (see Fig. 5).

Bare metal parts in VideoCom's field of view have no effect when they do not reflect light directly into VideoCom. If this problem should occur (e.g. from the rail of the linear air track), it can be solved by varying the height of VideoCom and thus the angle of incidence of the light flashes.

3.2.2 Adjusting VideoCom for measuring intensities

The stand rod included in the scope of supply enables you to use VideoCom on an optical bench for optics experiments. Depending on the experiment, you can dismount the lens using the hex screws ⑱. When VideoCom is switched to intensity measurement using the software or the MODE key ⑧, the bottom line of the LC display ⑦ indicates the measured intensity distribution.

To obtain satisfactory experiment results, you need to adjust the axes of the optical arrangement very carefully. Begin this process starting with the light source (left side) and VideoCom (right side). The light source (e.g. laser) and VideoCom should be aligned so that both units lie precisely on the optical axis. Then set up the remaining components working from left to right, always taking care not to disturb the optical axis. You also need to make sure that the beam path is as parallel as possible in front of the diffraction object.

Note

VideoCom only measures the intensities along a line. Light which passes through the lens diagonally upward or downward does not fall on the CCD line.

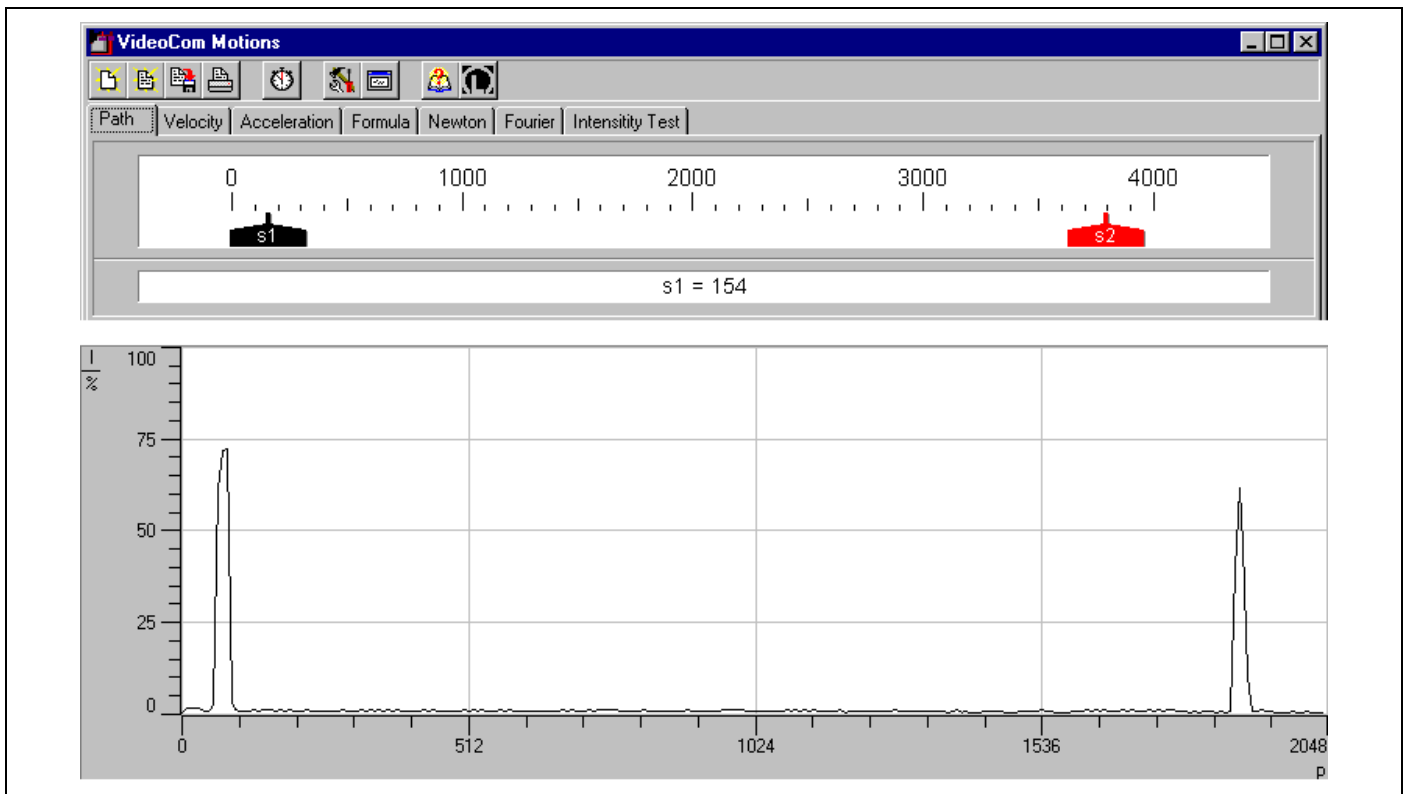


Fig. 5

The correctly aligned camera detects two reflections at the left and right edges of the motion even at the edge of the CCD (top: motion recording, bottom: intensity test). In this example, the intensity of the background is below 10 %, and the intensity of the reflections is greater than 25 %. The positions of the left and right edges of a reflection are used to determine the displayed pixel coordinates.

For later calibration, specifying e.g. the distance between the two reflections is sufficient.

3.2.3 Interference in intensity measurements

In principle, the problem of interference arises whenever measurements are conducted with coherent light. When using Video-Com, two types of interference occur:

- Laser light passes through the lenses and the glass window of the CCD.
Due to the great coherence length of the laser light, scattering and reflection can give rise to constructive and destructive interference. The resulting intensity fluctuations amount to no more than approx. 5 % (see Fig. 6 left). Such scattering plays no significant role, e.g. when an intensity distribution diffracted by a half-plane (edge) is divided by the undiffracted distribution (see Fig. 6 right). When measuring intensities for diffraction at a slit or multiple slit, however, these variations in the given intensity can interfere with the measurement.

- Coherent light of different wavelengths falls on different pixels of the CCD.
Between the surface of the CCD and the light-sensitive layer, there is an additional layer (a few μm thick). The interference occurring in this thin layer also alters the intensity incident on the light-sensitive layer. This change is wavelength-dependent and is apparent e.g. in the measured intensity distribution in the first order of diffraction of a grating (see Fig. 7 left). Here as well, the interference phenomena have no significant effect, e.g. when a filtered intensity distribution is divided by the unfiltered distribution (see Fig. 7 right).

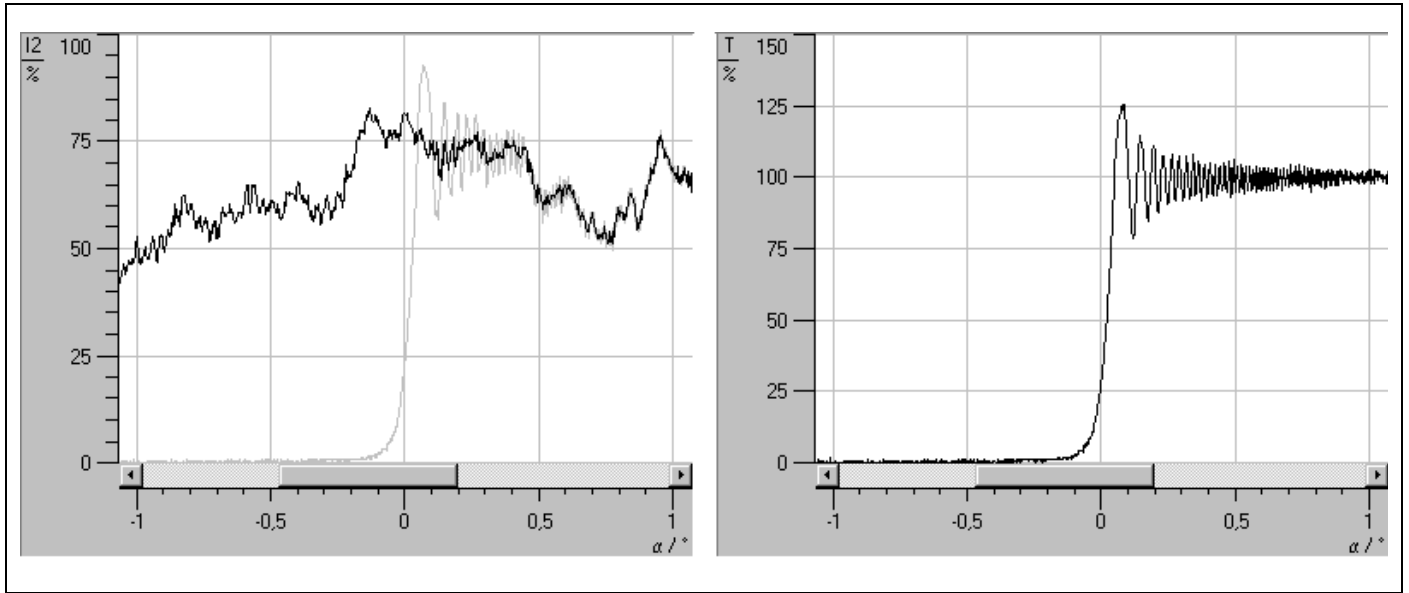


Fig. 6 Measured intensity distribution of a laser beam broadened by lenses (left, black curve) and the corresponding relative intensity distribution after diffraction at a half-plane (right, ratio of the left gray curve to the black curve).

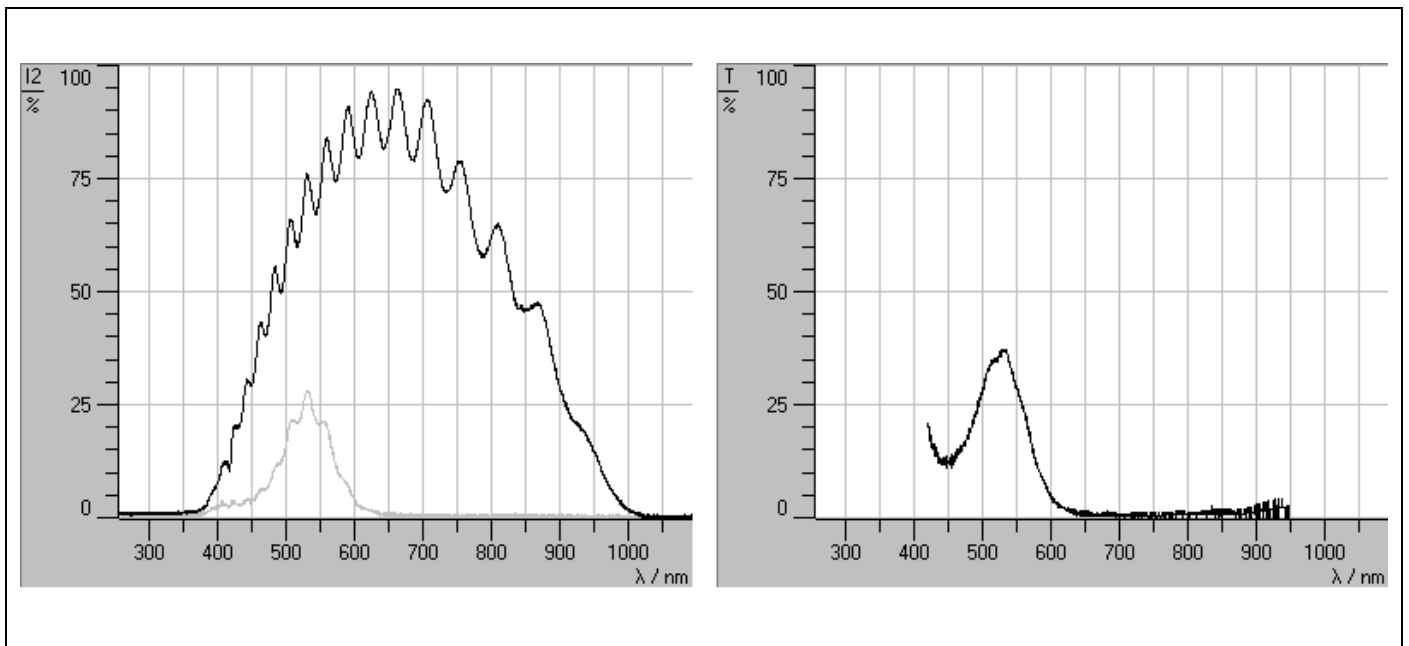


Fig. 7 Measured intensity distribution in the first order of diffraction of a grating (left, black curve) and the corresponding relative intensity distribution behind a green filter (filter transmission curve, right, ratio of the left gray curve to the black curve).

3.3 Retroreflecting foil

Strips of this self-adhesive foil can be cut from the sheet using a scissors and easily attached to a number of moving bodies (e.g. wrapped around the interrupter flags of a trolley or a bar pendulum) to permit registration of the motions of these bodies.

Good measuring results can only be obtained using clean, undamaged foil.

Do not cut the strips too small. The width of the strip should be about 0.5 to 1 % of the total path length. The height of the strip is critical for reliable adjustment of VideoCom, and should be at least 5 % of the path length. The higher the strip, the easier it is for VideoCom to detect the reflection, as well as to image reflections from the left and right edges of the picture simultaneously, i.e. track the reflections over the entire range of the motion.

3.4 Software

To install the software, you need a computer on which Windows 95 or Windows NT are properly installed.

Installation is carried out by the program SETUP.EXE on the disk after you have specified the desired language and installation directory.

Once installation is complete, the programs "Motions" and "Intensities" may be found in the Start menu under "Software" → "VideoCom".

If the software cannot find VideoCom on starting, it outputs a corresponding error message (possible causes: voltage source or serial cable not properly connected, wrong serial interface). You can change the serial interface by pressing key F5 (dialog box "Setup" → tab "General"); you can save this setting by clicking on "Save New Settings".

You can uninstall the software at any time using the Software icon in the Control Panel.

Both programs contain detailed help on the use of all functions. You can access this help with F1 after starting the respective program, and print it out if desired. These help systems also contain a great many practical hints and experiment notes. If you have any questions, please read these help texts before calling our hotline (+49-2233-604207).

All future software updates (extensions, patches) will be made available as they appear free of charge on our website <http://www.leybold-didactic.de>.