

## Report and Recommendations on Available Multimedia Material for Teaching Optics at School and at University Level

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### 1. Collection of Links

The authors are members of the working group (WG5) on Multimedia (MM) established by EUPEN (European Physics Education Network, <http://inwfnu07.rug.ac.be/eupen/>). The purpose of this report is to recommend good MM material for teaching optics. The members of WG5 examined approximately 220 links to sites with multimedia content, which are compiled in a list (see appendix 1). Due to iterative searches we are sure to have collected most, but not all material available (~90%). This collection of links to multimedia for teaching optics was obtained researching the internet, using several relevant databases (e.g. <http://www.merlot.org/>, <http://kbibmp5.ub.uni-kl.de/> and others). The list is structured in chapters following standard textbooks on optics (sometimes it was not obvious to add a specific MM material into a certain chapter). The material was distributed as follows:

Electromagnetic Waves in Vacuum	15 links
Electromagnetic Waves in Matter	43 links
Geometrical Optics	58 links
Interference and Diffraction	48 links
Optical Instruments and Techniques	14 links
Collections of Applets	2 links
Optical Tutorials	39 links

While collecting material the authors removed some of the links because of minor quality or because they were only a replication of material already incorporated (<5%).

### 2. Evaluation Procedure

Generally speaking, the process of evaluation contains four steps: 1<sup>st</sup> to set up a list of criteria, 2<sup>nd</sup> to agree on standards, 3<sup>rd</sup> to apply these standards on the material (analysis) and 4<sup>th</sup> to draw conclusions and to make recommendations (synthesis). The third step of the evaluation procedure was performed in the following way: The links (about 200) were distributed among the members of WG 5. More than one member evaluated each single multimedia product applying the list of criteria (see appendix 2, Altherr, S. et al: Multimedia Material for Teaching Physics (Search, Evaluation and Examples); European Journal of Physics, 25 (2004). As a consequence we established an overview judgement – general comments – and we selected only very few examples, which we consider to be excellent for teaching.

### 3. General Comments

- nearly all sites could be accessed and contain working material
- most sites are not appealing and are hard to navigate
- the URLs are too long and cryptic
- advertisements and pop-up windows are annoying on some sites
- a few pages require a free registration
- most sites do only collect material from other sources
- often there is no good concept for selecting and delivering the material
- 80 - 90% of the material is about standard topics (e.g. Young's' Double Slit Experiment)
- many optical tutorials do not use the possibilities of multimedia material
- most material (95%) are applets
- the material is often too simple and not instructive
- some material is of good quality but cannot be recommended for self-learning due to missing guidance or tutorial
- applications using technical or biological phenomena could utilise the full potential of multimedia
- many products deliver smart solutions for their special setting (e.g. within the lectures of the developer) but not for outside use
- most media are of mediocre quality at best
- whoever starts to produce material should research on what is already available
- so far, only English material has been evaluated; the inclusion of other languages should be considered
- all pages were evaluated using broadband connections; long loading times could occur using a modem
- some material contain good ideas, which can be combined and developed further in new products

### 4. Recommended Internet Websites

- Light and Optics: The Online Meteorology Guide  
([http://ww2010.atmos.uiuc.edu/\(Gh\)/guides/mtr/opt/home.rxml](http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/opt/home.rxml))  
This site, maintained by the University of Illinois, is a collection of web-based instructional modules. These incorporate text, colourful diagrams, animations, computer simulations, audio and video to introduce fundamental concepts in the atmospheric sciences. For teaching optics, only the section "Light and Optics" is relevant. This site delivers a good and motivating introduction; especially suited for high school level. The level of physics can be considered "easy".
- NTNU Virtual Physics Laboratory  
(<http://www.phy.ntnu.edu.tw/java/index.html>)  
The page is prepared by Associate Prof. Fu-Kwun Hwang from National Taiwan Normal University. The pages are available in different languages: English, Chinese, Korean, Dutch, Japanese, Portuguese, parts in French and Spanish. On the main page there are links to 14 sub pages on light and optics, each sub page contains interactive java applets. Other topics in physics are also available. The applets work flawlessly, and there exist good descriptions of how to explore the facilities of the applets. Some of the topics are addressed in a non-traditional way, but only a few of the pages include descriptions of the physical content.

- Science, Optics & You  
(<http://micro.magnet.fsu.edu/optics/index.html>)  
These web pages have been built up by Prof. M.W. Davidson (Florida State University in co-operation with National High Magnetic Field Laboratory). They give a very detailed introduction to questions related to light, colour and optics. The programme begins with basic information about lenses, shadows, prisms, scientific instruments, leading up to a microscopic analysis of a variety of samples in multiple ways. It contains many images, virtual microscopes and other applets and explains the content in great detail.  
The site goes much beyond the standard topics, has a clear objective and utilises a clever mix of text, photos, applets, videos etc. The interactive applets are accompanied by teacher resources, tutorials and proposals for student activities.
- Optical reconstruction  
(<http://www.mapageweb.umontreal.ca/hamamh/teach.htm>)  
This is the home page of Dr. Habib Hamam, University of Montreal, Canada. It delivers an interactive course in geometrical optics. More than 20 applets show how to reconstruct images through lenses, plain mirrors, spherical mirrors, equivalent systems, association of optical elements and human eyes. The applets are programmed nicely; some of them take a very long time to load, while others are too sophisticated for most users. There are no hints how to use the material included.
- Paul Falstad's Home Page  
(<http://www.falstad.com/mathphysics.html>)  
Paul Falstad is a programmer, who wrote several applets to help visualize various concepts in mathematics and physics. Of special interest for our purpose are the applets on the Ripple Tank and on Fresnel diffraction. This site also includes some interesting applets on electrodynamics. A link to some help about using the applets and about the physical setting (mainly university level) is found on all pages. The source codes of the Java programs are attached to the pages.

## **Acknowledgements**

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## Appendix 1: Collection of links for teaching optics (November 2002)

### **Electromagnetic Waves in Vacuum**

<http://lectureonline.cl.msu.edu/~mmp/applist/CYMCOLOR/c.htm>  
<http://lectureonline.cl.msu.edu/~mmp/applist/RGBColor/c.htm>  
<http://lectureonline.cl.msu.edu/~mmp/applist/Spectrum/s.htm>  
[http://www.explorescience.com/activities/Activity\\_page.cfm?ActivityID=36](http://www.explorescience.com/activities/Activity_page.cfm?ActivityID=36)  
[http://www.explorescience.com/activities/Activity\\_page.cfm?ActivityID=37](http://www.explorescience.com/activities/Activity_page.cfm?ActivityID=37)  
<http://ir.chem.cmu.edu/irproject/applets/color/Applet.asp>  
<http://www.phy.ntnu.edu.tw/java/image/rgbColor.html>  
[http://www.phy.ntnu.edu.tw/java/color/color\\_e.html](http://www.phy.ntnu.edu.tw/java/color/color_e.html)  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/light/additive.html>  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/light/subtractive.html>  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/colorstructure/index.html>  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/colorseparation/index.html>  
[http://www.fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter07/free/ausbreitung\\_elektromagnetischer\\_wellen.html](http://www.fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter07/free/ausbreitung_elektromagnetischer_wellen.html)  
[http://www.fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter07/free/energietransport\\_elektromagnetischer\\_wellen.html](http://www.fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter07/free/energietransport_elektromagnetischer_wellen.html)  
[http://www.fernstudium-physik.de/medienserver/mediafiles/realvideo/free/foucault\\_dr.rm](http://www.fernstudium-physik.de/medienserver/mediafiles/realvideo/free/foucault_dr.rm)

### **Electromagnetic Waves in Matter**

<http://lectureonline.cl.msu.edu/~mmp/kap25/Snell/app.htm>  
<http://lectureonline.cl.msu.edu/~mmp/kap13/cd372.htm>  
<http://lectureonline.cl.msu.edu/~mmp/kap24/polarizers/Polarizer.htm>  
<http://www.phy.ntnu.edu.tw/java/Rainbow/rainbow.html>  
[http://www.fernstudium-physik.de/medienserver/mediafiles/realvideo/restricted/brechung\\_in\\_der\\_atmosphaere.rm](http://www.fernstudium-physik.de/medienserver/mediafiles/realvideo/restricted/brechung_in_der_atmosphaere.rm)  
<http://www.fernstudium-physik.de/medienserver/mediafiles/realvideo/restricted/brechungsindex.rm>  
<http://fernstudium-physik.de/medienserver/mediafiles/realvideo/free/Absorption-Emission.rm>  
<http://fernstudium-physik.de/medienserver/Mediafiles/Applets/ourfun/Brechung/lightrefract.htm>  
[http://fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter08/restricted/brechung\\_und\\_totalreflexion.rm](http://fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter08/restricted/brechung_und_totalreflexion.rm)  
[http://fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter09/restricted/doppelbrechender\\_kristall.html](http://fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter09/restricted/doppelbrechender_kristall.html)  
<http://fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter08/free/doppelbrechung.rm>  
[http://fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter08/free/durchgang\\_einer\\_ebenen\\_welle\\_durch\\_ein\\_medium.html](http://fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter08/free/durchgang_einer_ebenen_welle_durch_ein_medium.html)  
<http://fernstudium-physik.de/medienserver/Mediafiles/Applets/xchaos5/Krug/WorkInProgress/WorkInProgress.html>  
<http://fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter07/free/mikrowellenbrechung.html>  
<http://fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter07/free/mikrowellenreflexion.html>  
[http://fernstudium-physik.de/medienserver/mediafiles/realvideo/restricted/rayleigh\\_streuung.rm](http://fernstudium-physik.de/medienserver/mediafiles/realvideo/restricted/rayleigh_streuung.rm)  
[http://fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter09/free/snelliussches\\_brechungsgesetz.html](http://fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter09/free/snelliussches_brechungsgesetz.html)  
<http://fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter09/restricted/totalreflexion.html>  
<http://www.fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter07/free/mikrowellenpolarisation.html>  
[http://www.fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter07/free/polarisation\\_elektromagnetischer\\_wellen.html](http://www.fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter07/free/polarisation_elektromagnetischer_wellen.html)  
<http://www.fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter07/restricted/polarisationsfilter.html>  
<http://fernstudium-physik.de/medienserver/Mediafiles/Applets/ourfun/Bragg/Bragg.html>  
[http://fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter11/free/dielektrischer\\_spiegel.html](http://fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter11/free/dielektrischer_spiegel.html)  
<http://physics.rug.ac.be/fysica/applets/snellius/index.htm>  
<http://www.msu.edu/user/brechtjo/physics/interfaceOptics/interfaceOptics.html>  
[http://www.physics.yorku.ca/undergrad\\_programme/highsch/Prism.html](http://www.physics.yorku.ca/undergrad_programme/highsch/Prism.html)  
[http://www.explorescience.com/activities/Activity\\_page.cfm?ActivityID=51](http://www.explorescience.com/activities/Activity_page.cfm?ActivityID=51)  
<http://www.msu.edu/user/brechtjo/physics/interfaceOptics/interfaceOptics.html>

<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/newton/>  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/reflection/index.html>  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/refraction/index.html>  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/birefringence/index.html>  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/virtual/polarizing/index.html>  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/polarizedlight/filters/index.html>  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/polarizedlight/crystal/index.html>  
<http://www.micro.magnet.fsu.edu/primer/java/polarizedlight/icelandspar/index.html>  
[http://ww2010.atmos.uiuc.edu/\(Gh\)/guides/mtr/opt/home.xml](http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/opt/home.xml)  
<http://www.kw.igs.net/~jackord/mo/w4.html>  
<http://www.physik.uni-wuerzburg.de/physikonline/video1/optik/o1versuch1.htm>  
<http://www.physik.uni-wuerzburg.de/physikonline/video1/optik/o1versuch9.htm>  
<http://www.physik.uni-wuerzburg.de/physikonline/video1/optik/o1versuch9.htm>

## **Geometrical Optics**

[http://www.explorescience.com/activities/Activity\\_page.cfm?ActivityID=52](http://www.explorescience.com/activities/Activity_page.cfm?ActivityID=52)  
[http://www.explorescience.com/activities/Activity\\_page.cfm?ActivityID=53](http://www.explorescience.com/activities/Activity_page.cfm?ActivityID=53)  
<http://www.explorescience.com/prism.htm>  
<http://lectureonline.cl.msu.edu/~mmp/applist/optics/o.htm>  
<http://lectureonline.cl.msu.edu/~mmp/applist/shadow/sh.htm>  
[http://webphysics.davidson.edu/Applets/optics4/spherical\\_aberration.html](http://webphysics.davidson.edu/Applets/optics4/spherical_aberration.html)  
[http://webphysics.davidson.edu/Applets/optics4/thick\\_lens.html](http://webphysics.davidson.edu/Applets/optics4/thick_lens.html)  
[http://webphysics.davidson.edu/Applets/optics4/dielectric\\_lens.html](http://webphysics.davidson.edu/Applets/optics4/dielectric_lens.html)  
[http://webphysics.davidson.edu/Applets/optics4/data\\_sources.html](http://webphysics.davidson.edu/Applets/optics4/data_sources.html)  
<http://surendranath.tripod.com/CurvSurf/CurvSurf.html>  
<http://surendranath.tripod.com/Prism/Prism.html>  
<http://www.phy.ntnu.edu.tw/java/light/flashLight.html>  
[http://www.phy.ntnu.edu.tw/java/Lens/lens\\_e.html](http://www.phy.ntnu.edu.tw/java/Lens/lens_e.html)  
<http://www.phy.ntnu.edu.tw/java/thinLens/thinLens.html>  
<http://www.phy.ntnu.edu.tw/java/thickLens/thickLens.html>  
<http://www.phy.ntnu.edu.tw/java/thickLens/thickLens.html>  
<http://www.phy.ntnu.edu.tw/java/fishEye/fishEye.html>  
<http://www.phy.ntnu.edu.tw/java/shadow/shadow.html>  
<http://www.phy.ntnu.edu.tw/java/billiards/billiards.html>  
<http://www.phy.ntnu.edu.tw/java/Fermat/Fermat.html>  
<http://www.phy.ntnu.edu.tw/java/pinHole/pinhole.html>  
[http://www.phy.ntnu.edu.tw/java/optics/prism\\_e.html](http://www.phy.ntnu.edu.tw/java/optics/prism_e.html)  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/shadows/index.html>  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/hinged/index.html>  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/lightbench/index.html>  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/lunar/index.html>  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/solar/index.html>  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/virtual/translational/index.html>  
<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/eyeball/index.html>  
<http://www.micro.magnet.fsu.edu/primer/java/lens/bi-convex.html>  
<http://www.micro.magnet.fsu.edu/primer/java/components/perfectlens/index.html>  
<http://mapageweb.umontreal.ca/hamamh/optics/shadow/Shad.htm>  
<http://www.mapageweb.umontreal.ca/hamamh/Optics/Aber/Aberration.htm>  
<http://www.mapageweb.umontreal.ca/hamamh/optics/Refract/refract.htm>  
<http://www.mapageweb.umontreal.ca/hamamh/optics/principal.htm#ConvLens>  
<http://www.mapageweb.umontreal.ca/hamamh/optics/principal.htm#DivLens>  
<http://www.mapageweb.umontreal.ca/hamamh/optics/principal.htm#ConvDiop>  
<http://www.mapageweb.umontreal.ca/hamamh/optics/principal.htm#DivDiop>  
<http://www.mapageweb.umontreal.ca/hamamh/optics/principal.htm#DivMir>  
<http://www.mapageweb.umontreal.ca/hamamh/optics/principal.htm#ConvMir>  
<http://www.mapageweb.umontreal.ca/hamamh/optics/principal.htm#ConEqSys>  
<http://www.mapageweb.umontreal.ca/hamamh/optics/principal.htm#DivEqSys>  
<http://www.mapageweb.umontreal.ca/hamamh/optics/principal.htm#twolens>  
<http://www.mapageweb.umontreal.ca/hamamh/optics/principal.htm#threelens>  
<http://www.mapageweb.umontreal.ca/hamamh/optics/principal.htm#lensmir>  
<http://www.mapageweb.umontreal.ca/hamamh/optics/TwoLensM/TwoLensM.htm>  
<http://www.mapageweb.umontreal.ca/hamamh/optics/principal.htm#planemir>  
<http://www.mapageweb.umontreal.ca/hamamh/optics/principal.htm#LenPlaM>  
<http://www.mapageweb.umontreal.ca/hamamh/optics/Zoom/zoom.htm>  
<http://pen.physik.uni-kl.de/physlets/scriptors/online/OpticsScriptor.html>  
[http://www.fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter10/free/duenne\\_linsen.html](http://www.fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter10/free/duenne_linsen.html)



<http://fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter12/free/lupe.html>  
<http://fernstudium-physik.de/medienserver/mediapages/experimentalphysics2/chapter12/free/mikroskop.html>  
[http://fernstudium-physik.de/medienserver/mediafiles/realvideo/restricted/co2\\_laser.rm](http://fernstudium-physik.de/medienserver/mediafiles/realvideo/restricted/co2_laser.rm)  
<http://fernstudium-physik.de/medienserver/mediafiles/realvideo/free/Natrium-Wellenlaengen.rm>  
<http://www.openteach.com/astronomy/telescope.html>  
<http://micro.magnet.fsu.edu/chipshots/index.html>

### **Collections of Applets:**

<http://www.ba.infn.it/~zito/museo/gemme.html#n10>  
<http://www.physik.uni-wuerzburg.de/physikonline/video1/optik/o1versuch9.htm>

### **Optical Tutorials**

<http://electron9.phys.utk.edu/136/modules/module10.htm>  
<http://electron9.phys.utk.edu/136/modules/module9.htm>  
<http://electron9.phys.utk.edu/optics421/>

#### **next three together:**

<http://kestrel.nmt.edu/~raymond/classes/ph13xbook/node3.html>  
<http://kestrel.nmt.edu/~raymond/classes/ph13xbook/node20.html>

#### **next six together:**

<http://pads1.pa.msu.edu/courses/1997spring/PHY232/lectures/emwaves/index.html>  
<http://pads1.pa.msu.edu/courses/1997spring/PHY232/lectures/refraction/index.html>  
<http://pads1.pa.msu.edu/courses/1997spring/PHY232/lectures/mirrors/index.html>  
<http://pads1.pa.msu.edu/courses/1997spring/PHY232/lectures/lenses/index.html>  
[http://pads1.pa.msu.edu/courses/1997spring/PHY232/lectures/op\\_instruments/index.html](http://pads1.pa.msu.edu/courses/1997spring/PHY232/lectures/op_instruments/index.html)  
<http://pads1.pa.msu.edu/courses/1997spring/PHY232/lectures/interference/index.html>  
<http://theory.uwinnipeg.ca/physics/light/index.html>  
[http://theory.uwinnipeg.ca/mod\\_tech/node109.html](http://theory.uwinnipeg.ca/mod_tech/node109.html)  
<http://scienceworld.wolfram.com/physics/topics/Optics.html>

#### **next five together:**

[http://www.physik.uni-erlangen.de/PI3/ustinov/seminars/ss\\_00/lectures/vorlesung-optik-1.pdf](http://www.physik.uni-erlangen.de/PI3/ustinov/seminars/ss_00/lectures/vorlesung-optik-1.pdf)  
[http://www.physik.uni-erlangen.de/PI3/ustinov/seminars/ss\\_00/lectures/vorlesung-optik-2.pdf](http://www.physik.uni-erlangen.de/PI3/ustinov/seminars/ss_00/lectures/vorlesung-optik-2.pdf)  
[http://www.physik.uni-erlangen.de/PI3/ustinov/seminars/ss\\_00/lectures/vorlesung-optik-3.pdf](http://www.physik.uni-erlangen.de/PI3/ustinov/seminars/ss_00/lectures/vorlesung-optik-3.pdf)  
[http://www.physik.uni-erlangen.de/PI3/ustinov/seminars/ss\\_00/lectures/vorlesung-optik-4.pdf](http://www.physik.uni-erlangen.de/PI3/ustinov/seminars/ss_00/lectures/vorlesung-optik-4.pdf)  
[http://www.physik.uni-erlangen.de/PI3/ustinov/seminars/ss\\_00/lectures/vorlesung-optik-5.pdf](http://www.physik.uni-erlangen.de/PI3/ustinov/seminars/ss_00/lectures/vorlesung-optik-5.pdf)

#### **use postscript version:**

[http://eeh01.physik.hu-berlin.de/~hebbeker/lectures/i390\\_ind.htm](http://eeh01.physik.hu-berlin.de/~hebbeker/lectures/i390_ind.htm)  
<http://hypertextbook.com/physics/waves/>

#### **next three together:**

<http://farside.ph.utexas.edu/teaching/302/lectures/node98.html>  
<http://farside.ph.utexas.edu/teaching/302/lectures/node105.html>  
<http://farside.ph.utexas.edu/teaching/302/lectures/node133.html>

#### **next seven together:**

[http://www.uni-tuebingen.de/uni/pki/skripten/V8\\_1Huygens.DOC](http://www.uni-tuebingen.de/uni/pki/skripten/V8_1Huygens.DOC)  
[http://www.uni-tuebingen.de/uni/pki/skripten/V8\\_2\\_4Auge.DOC](http://www.uni-tuebingen.de/uni/pki/skripten/V8_2_4Auge.DOC)  
[http://www.uni-tuebingen.de/uni/pki/skripten/V8\\_2\\_5Linsen.DOC](http://www.uni-tuebingen.de/uni/pki/skripten/V8_2_5Linsen.DOC)  
[http://www.uni-tuebingen.de/uni/pki/skripten/V8\\_2\\_8Farben.DOC](http://www.uni-tuebingen.de/uni/pki/skripten/V8_2_8Farben.DOC)  
[http://www.uni-tuebingen.de/uni/pki/skripten/V8\\_3Polarisation.DOC](http://www.uni-tuebingen.de/uni/pki/skripten/V8_3Polarisation.DOC)  
[http://www.uni-tuebingen.de/uni/pki/skripten/V8\\_4Beugung.DOC](http://www.uni-tuebingen.de/uni/pki/skripten/V8_4Beugung.DOC)  
[http://www.uni-tuebingen.de/uni/pki/skripten/V8\\_4AFourier.DOC](http://www.uni-tuebingen.de/uni/pki/skripten/V8_4AFourier.DOC)  
[http://www.ifp.uni-bremen.de/ryder/lv/gk/opt\\_print.pdf](http://www.ifp.uni-bremen.de/ryder/lv/gk/opt_print.pdf)  
<http://www.tfp.physik.uni-karlsruhe.de/~didaktik/skripten/optik.pdf>  
[http://www.physik.rwth-aachen.de/group/IIIphys/INFOS/Fluegge\\_Vorl/ow.ps.gz](http://www.physik.rwth-aachen.de/group/IIIphys/INFOS/Fluegge_Vorl/ow.ps.gz)  
[http://www.valdosta.edu/phy/astro/pl\\_shows/color\\_2000/first\\_page.htm](http://www.valdosta.edu/phy/astro/pl_shows/color_2000/first_page.htm)

#### **See „Matrix Wave Optics“:**

<http://www.kw.igs.net/~jackord/j6.html#p1>  
<http://id.mind.net/~zona/mstm/physics/light/light.html>  
<http://www.physics.yorku.ca/Undergraduate/tutorials.html>

## Appendix 2: List of criteria to evaluate multimedia material

In evaluating multimedia material (MM) we see three major steps: The first one covers the question, if easy technical access to the MM is possible, and if a willingness, to work with it, is stimulated. If the user is still motivated to work with the MM, the content has to be checked next. Finally, apart from content and motivation, the product should be examined with regard to teaching implementation, methods and teaching environment.

<p style="text-align: center;"><u><b>motivation</b></u></p> <ul style="list-style-type: none"> <li>• user-friendliness</li> <li>• attractiveness</li> <li>• clear description of purpose and work assignment</li> </ul>	<p style="text-align: center;"><u><b>content</b></u></p> <ul style="list-style-type: none"> <li>• relevance</li> <li>• scope</li> <li>• correctness</li> </ul>	<p style="text-align: center;"><u><b>method</b></u></p> <ul style="list-style-type: none"> <li>• flexibility</li> <li>• matching to target group</li> <li>• realization</li> <li>• documentation</li> </ul>
<p><u>User-friendliness:</u>            Is it easy to start using the MM?            Are the design comprehensible and the image quality satisfactory?            Is the function of control elements evident?            Are the software requirements clear and of adequate proportion?</p> <p><u>Attractiveness:</u>            Is the layout appealing?            Is there a motivating introduction?            Are there interactive components?            Is the topic interesting (reference to everyday life, applications, explaining a phenomenon)?            Is the MM up-to-date / innovative?</p> <p><u>Clear description of purpose and work assignment:</u>            Is the intention of the MM evident?            Does the user know what is expected from him?            Is there a problem to solve or a context to understand?</p>		
<p><u>Relevance:</u>            Is the topic important?            Does it make sense to use the MM (e.g. problems in understanding, dynamic process)?</p> <p><u>Scope:</u>            Is there a profoundness of content?            Is there a broadness of content (special case, general overview)?</p> <p><u>Correctness:</u>            Is the content of the MM correct?            Are simplifications indicated?</p>		
<p><u>Flexibility:</u>            Is the MM appropriate for a broad target group (incl. self-learning)?            Is it possible to use the MM in different teaching and learning situations?            Does the MM allow for the same topic to be approached in different ways?</p> <p><u>Matching to target group:</u>            Is a reasonable didactical reduction implemented?            Are technical terms explained?            Are the objectives appropriate?</p> <p><u>Realization:</u>            Is the general approach suitable to present the subject and realize aims of the given MM?            Is the type of MM chosen reasonable (video, simulation, animation)?</p> <p><u>Documentation:</u>            Is the operation obvious or explained?            Is the material self-evident or explained by additional text?            Is there a reference to material for further studies?            Are there any suggestions for implementation into the teaching process?</p>		