Report and Recommendations on Available Multimedia Material for Statistical and Thermal Physics

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1. Introduction and Background

Multimedia teaching and learning materials are now a common addition to classes in physics at all levels; they are used to expand the setting and scope of the standard classroom. Simulations, video, online tutorials, and virtual classroom demonstrations are being developed around the world and are published as supplements to many standard introductory physics textbooks. However, physics teachers and faculty need help finding and effectively using multimedia in their classes. Many do not have the time or experience to locate the resources and evaluate their potential for improving their class. The primary goal of the work described in this report is to identify multimedia resources in thermodynamics and statistical mechanics that have the potential to significantly improve physics courses. Other goals of this work to provide a broad view of the functionality and topical coverage of existing multimedia resources, to find areas where more development is needed, and to compare and contrast independent evaluations of multimedia materials to determine if there exists a consensus as to what represents high quality.

This report is the fourth in a series presented at MPTL workshops since 2002. At the MPTL workshop in Parma (2002), our members of the former EUPEN (European Physics Education Network) presented reviews and analysis of materials on Quantum Mechanics at the university level [1], and in Prague (2003) we focused on Optics at both the pre-university and university levels [2]. Last year this group collaborated on a review of resources on Mechanics at all levels [3] with the members of the MERLOT/Physics editorial board. MERLOT is based in the United States and has been performing reviews of multimedia resources in 15 different disciplines since 2000 [4].

The decision to review materials in thermal and statistical physics this year was made for a number of reasons. Thermodynamics and statistical mechanics are subjects where computer-based simulations and animations have an important role to play in the learning process. These subjects involve connections between macroscopic and microscopic properties that are not readily observable, particularly the statistical description of systems. Thermodynamic processes often occur on time scales that are too long for useful in-class demonstrations and the demonstrations do not clearly present the underlying physical concepts. For example, observing the operation of a real engine does not show the thermodynamic processes involved, nor develops conceptual understanding of these processes. Finally, it is our goal to complete evaluations of all of the standard physics topics over the next few years, and thermal and statistical physics is an important part of the physics curriculum.

2. Process

The process followed in these evaluations has been described in previous reports and publications. Here we briefly outline the steps in the evaluation process. They correspond to discovery of materials, initial selection of materials to be reviewed, detailed evaluation of selected materials, and the final comparison and analysis of the results of the reviews.

a. Collection of Links

The EPS group developed a list of links to approximately 110 multimedia thermodynamics resources (see Appendix 1) through searching the internet and using several relevant databases.

The resources found varied greatly in size and coverage, from single applets focused on a detailed topic to broader online textbooks and resource databases. Poor quality materials and replications appearing on multiple sites were removed from this list. Unlike the list created for Mechanics from last year, which was more than twice the size, this initial list was not broken into topical areas at this stage.

The MERLOT database used in this study has been developed through searches similar to that performed by the EPS group and through submissions by users of MERLOT. It contains approximately 75 items in the areas of thermodynamics and statistical mechanics. It is available online. There was overlap between the MERLOT and EPS lists, although this process indicated the need to expand the MERLOT database for these topics.

b. Preliminary Evaluations

Each group performed a preliminary review of the resources identified in their lists to select those items suitable for a full evaluation. This makes the review process more efficient because of the time necessary to perform a detailed review. The preliminary evaluations involved each resource being accessed by one reviewer who selects those items likely to be reviewed as good or excellent quality. This process is a regular step in the processing of resources on MERLOT where unsuitable items are removed and high quality items are added to a list of high-priority reviews.

The results of the preliminary evaluations by the EPS group and the MERLOT group were next combined into a single list of materials selected for the final evaluations. This combined list (see Appendix 2) was broken into sub-topical areas, similar to what would be found in a standard textbook on thermal physics. This was done for organization and to help analyze coverage of topics. The breakdown of these subtopics is given in the following table.

Topical Breakdown of Resources for Final Evaluation	
Topic	**Number**
General Collections, Courses and texts	7
Laws of Thermodynamics	3
Ideal Gas Processes	4
Engines and Ideal Gas Cycles	5
Kinetic Theory: Velocity Distribution	6
Kinetic Theory: Pressure, Temperature, Diffusion, and Equilibrium	6
Kinetic Theory: Brownian Motion	5
Stat Mech: Energy Levels and Boltzmann	2
Heat Diffusion	3
Radiation	6
Quantum Statistics: Fermi Distribution	4
Materials Properties: Magnetism and Dielectrics	3

This list of materials included some items that, upon detailed review, were rated as low quality. This indicates the insufficiency of quick impressions of materials and the need for detailed evaluations.

c. Final Evaluations

Each of the items identified from the preliminary evaluation was reviewed by one member of each of the teams, the EPS group and MERLOT. These reviews were performed independently to provide a test of the consistency and repeatability of review results. The rubrics used by the two groups were somewhat different, again to determine if independent review processes identify similar resources as being of high quality. The two groups have compared evaluations of materials from previous efforts and there is very good agreement between the results of the review processes.

The *EPS group* followed a list of evaluation criteria that was accepted by all participants of the MPTL workshops in Parma and Prague and has been published [5]. The rubric form (see Appendix 3) gives short questions that are used to judge materials in the overall categories of **Motivation**, **Content**, and **Method**. A 5 level score (-2 to 2) is used in the rubric to give an overall score for each item. The MERLOT review process is similar, although with a different rubric used for the evaluation. Three overall categories of **Quality of Content**, **Potential Effectiveness for Teaching and Learning**, and **Ease of Use** are defined by 4 or 5 questions used to review materials. Reviews provide scores on a 1 to 5 scale for each of the three categories and an overall score. Because these reviews are meant to help teachers and students discover learning resources and recognize the efforts of the authors, the completed MERLOT reviews are available online. Details of the MERLOT review process and the rubric are all available online [6].

The analysis of the resource evaluations consisted of comparing the results of the independent reviews of each item, and identifying common themes from comments on the materials evaluated. General impressions of the materials in thermal physics are gathered along with detailed recommendations for the highest quality resources. These results are presented below.

3. General comments

The following list summarizes our general impressions of the thermal and statistical physics resources reviewed in this process. These statements are meant to be a review of the field and constructive criticism.

Comments regarding materials:

1. There is a general feeling that although there were several resources that are "very good", only one would be considered "excellent". "Excellent" materials are those that are considered in the top 10 percent of all physics multimedia resources reviewed. This is fewer than found for topics previously reviewed.
2. Several reviewers felt that the connection between classical and statistical mechanics, between the macro-physics and the mirco-physics, was not sufficiently covered. Multimedia should be a powerful tool for doing this.
3. Many of the simulation applets involve simple animations of bouncing dots representing gases, liquids, or solids, with little interactivity or exploration by students possible. In these cases, some limited set of input parameters can be set, the simulations run, and some limited (if any) qualitative results viewed. Brownian motion, in particular, suffers from this problem.
4. Many reviewers expressed the problem that items are too narrow. They cover only a single detailed topic, such as a particular heat engine cycle or a simple discussion of black body radiation. A related problem is that many resources lack didactic materials to put them in context and simplify their use in class.
5. Several of the resources reviewed were not complete, or are "works in progress" rather than polished materials. When these sites are completed, it would improve the available multimedia resources for thermal physics.
6. Physlets were not included in the list of Excellent and Very Good items, although there are many examples of good uses of Physlets as building blocks for specific uses. Broader topical collections of combined multimedia and didactic materials tended to receive higher reviews.
7. One item presents incorrect physics in a parameter regime outside of where it can operate. This is probably the result of insufficient checking of inputs. Three items have displays that are not clear for some browsers. Otherwise, materials ran well and presented correct results.
8. Three of the items identified for review were connected to courses and were no longer available when the reviews were performed. If recommendations of the sort provided by this report are going to be useful for faculty, constant monitoring and refresh is important.

Comments regarding reviews:

1. So far, only materials in English have been evaluated because this is the common language of the reviewers. The inclusion of other languages should be considered; in this case resources in German and Spanish were identified as being potentially very good, but not reviewed because of language.
2. There are some small disagreements between reviewers as to what is "excellent". These are usually due to different views of the breadth and amount of didactic materials in an excellent item. However, all items rated as "excellent" by one reviewer are rated "very good" by the other.
3. There is some disagreement on what constitutes effective use of multimedia. A common example is programs that output static graphs for a given set of input parameters. Some reviewers felt this no better than static images found

in a textbook while others felt the ability to explore parameters and output different graphs was an advantage of the multimedia.

4. Commercial materials (e.g. CDs connected to textbooks) were not included in this evaluation.

4. Recommended Resources and Websites

The following are the recommendations and comments for the Excellent and Very Good resources identified in this review. The EPS evaluation forms for the Excellent item and some of the Very Good items are available in Appendix 4. The MERLOT reviews of many of these items are online. We have also included two large collections of materials that are not in English, and thus were not reviewed, but the reviewers felt are worth considering.

Excellent Materials:

The Expert System for Thermodynamics (TEST): Prof. S. Bhattacharjee, San Diego State University, http://energy.sdsu.edu/testcenter

This is a comprehensive website on thermodynamics. The central feature of this material is an extensive set of "daemons", thermodynamic calculators that can be used to simulate a wide range of thermodynamic problems and systems. Included on the site is a virtual thermodynamics tutorial system that uses multimedia to illustrate basic thermodynamic concepts and applications such as engines and refrigerators. TEST also includes a large number of problems and examples to use in a class. It is important to note that this web site is developed for engineering applications. There is no statistical physics included and the microscopic pictures presented are very basic and simplified.

Very Good Materials:

Statistical and Thermal Physics Curriculum Development Project (STP): Harvey Gould, Clark University and Jan Tobochnik, Kalamazoo College, http://stp.clarku.edu.

The goal of this project is the collaborative creation of an open source curriculum in statistical and thermal physics. An important product of this effort is a collection of 23 simulations that are part of the Open Source Physics project. The site also includes an extensive set of lecture notes, an annotated list of text books, suggested demos and conceptual questions for this subject, and links to other resources. The level of this material is upper university or early graduate school. This is an ongoing development effort with the potential to be excellent.

Statistical Physics: Franz J. Vesely, University of Vienna, http://homepage.univie.ac.at/Franz.Vesely/sp_english/sp/sp.html (Text with applets), http://homepage.univie.ac.at/Franz.Vesely/grc2000/bx/ (Presentation outline with applets)

This is an online textbook on Statistical Physics, with Java applets imbedded to illustrate the properties being studied. The applets themselves, with a discussion of the approach to the physics being used, are listed in the presentation outline (second link above). The text is mostly a standard (non-multimedia) presentation, but the applets provide compelling illustrations of statistical properties and the simple microscopic physics that can be used to explain macroscopic thermodynamics. Problems for students are provided on the various topics covered, some of which use the applets for comparison to calculations.

Gas Law Program: Michael Abraham, University of Oklahoma, John Gelder, Kirk Haines, Oklahoma State University, http://intro.chem.okstate.edu/1314F00/Laboratory/GLP.htm

This is a good example of an illustration of kinetic theory for an ideal gas. It can simulate a gas with either one or two types of atoms (He and Ne), and all parameters can be changed. An illustration of the gas as colliding spheres is shown and a wide range of graphs of thermodynamic properties can be created and compared. Instructions for using the applet and examples of inquiry activities using the simulation are included.

Osmosis: Paul Zitzewitz, University of Michigan-Dearborn, http://curie.umd.umich.edu/Physlets/osmosis.html

This is an example of a very well done, very focused use of Physlets to demonstrate the physics of osmosis. The simulation shows two ideal gasses separated by a semi-permeable membrane that can transmit one of the two gasses. Changes in number and pressure are shown and the particles diffuse through the membrane. Questions to help students explore the physics of this system are included.

The Maxwell-Boltzmann Distribution: Andrew Rappe, University of Pennsylvania, http://lorax.chem.upenn.edu/Education/MB/index.html

This web site illustrates the way in which the Maxwell-Boltzmann distribution of energies can be related to the equilibrium properties of the random motion of a gas. A 3D simulation of a gas of atoms, interacting through a Lennard-Jones potential, shows the approach to equilibrium. A series of tutorial pages develop the physics of the distribution and include questions for students to consider.

The Semiconductor Applet Service: Prof. C.R. Wie, University at Buffalo, SUNY, http://jas.eng.buffalo.edu/ (also http://jas2.eng.buffalo.edu/applets/)

This is web site covering the physics and design of semiconductor electronic devices, including a large number of simulations and illustrations of physical processes. Although the focus of this site is not strictly thermodynamics and statistical physics, there are several applets illustrating the properties of Fermi Statistics. Included with these applets is reference material on the physics and mathematics of these systems and worksheets for students to use to explore the subject. This material is aimed at an upper level university audience, both for a semiconductor physics class and as applications of quantum statistics in a statistical physics class.

Statistical Mechanics Simulator: The Chemistry Collective, Carnegie Mellon University, http://www.chemcollective.org/applets/statmech.php

This java applet is unique in the manner it connects the microscopic to the macroscopic. The user can create an energy level diagram for a system and the applet will plot properties such as energy level population, the partition function, and the heat capacity as a function of temperature. Unfortunately, this simulation is without instructions on how it runs and didactic resources for incorporating it into a classroom setting. The Chemistry Collective project, which is responsible for this applet, is creating such additional materials for a number of different applets so that hopefully, in the future, they will be available for this one.

Non-English Materials:

Physikonline Thermodynamik: Tilo Hemmert, Universität Würzburg, http://www.physik.uni-wuerzburg.de/physikonline/thermodynamik/thermodynamik.html

This extensive web site contains a collection of short explanations of thermodynamic properties and principles, with many connected to short videos of experiments demonstrating the physics. This connection of theory to experiment was highlighted as an important aspect of this collection.

Física Estadística y Termodinámica: Angel Franco Garcia, Universidad del País Vasco
http://www.sc.ehu.es/sbweb/fisica/estadistica/estadistica.htm

This is one of 13 chapters of an online textbook for physics. It incorporates java illustrations and simulations into the text for a richer instructional environment. Questions and activities tied to the applets make the material more interactive and tutorial in nature. The power of this resource is the connection between the text and the simulations.

5. Conclusion and future work

The resources found in this review process are useful for statistical and thermal physics course. There are not as many examples of comprehensive collections of materials combining multimedia resources and methods for using them in class as was found in classical and quantum mechanics, but it is similar to optics. This may be due to the breadth and depth these topics are covered in standard courses, with classical quantum mechanics being covered in several courses in most curricula and much less time being spent on thermal and statistical physics. The resources reviewed often lack interactivity, being simple illustrations of “bouncing balls”. Interactive, multimedia presentations of statistical are more difficult to create due to the microscopic, multi-particle nature of the subject. We found that connections to didactic materials are often lacking for these resources, but there are a couple of projects underway that may solve this problem. We also suggest that greater use of multimedia to connect microscopic physics to macroscopic properties be developed.

Similar to previous reviews, we find very good agreement between independent reviews of multimedia learning materials. This indicates a general consensus among experienced teachers about what is useful for teaching and learning, even where review rubrics and methods vary. It is possible that the standards used by reviewers have risen as they have gained experience in evaluating these multimedia resources, although a careful study of this has yet to be performed. We also find, as in the past, a repetition of standard examples, such as Brownian motion and kinetic theory simulations. If the development of multimedia learning is to be a more efficient and scholarly enterprise, there is a need for better methods of disseminating this work around the world. Reducing repetition of effort will increase the possibilities for improving the learning outcomes from these resources, and meeting unfulfilled needs. We applaud efforts underway to create partnerships for development of multimedia learning resources and encourage developers to join these efforts.

As we stated in last year's report, it is important to note that the reviews performed here can not replace careful assessment studies of the learning potential of objects. Scientific learning assessment is vital, but the goals of reviews and assessments are different. Good assessment is a careful study that takes a great deal of time. Reviews are quicker recommendations from experienced teachers for a wide range of resource types and topics. The reviews performed here are not a scientific assessment just as peer reviews of scientific work do not require an exact repeat of the research. However, reviews should make use of the results of learning assessments, and assessed materials should receive high priority for review.

We suggest that Electricity and Magnetism be the next topic reviewed. We will also explore ways to perform reliable reviews of resources not in English.

References

[1] M. Benedict, E. Debowska, H. J. Jodl, L. Mathelitsch, R. Sporken, “Reccomendations (for material on quantum mechanics and for evaluation criteria)”, 7th Workshop on Multimedia in Physics Teaching and Learning of the European Physical Society – Proceedings, (Parma, Italy 2002), available online http://informando.infm.it/MPTL/proceedings/WG5_rec1.PDF (Accessed 9/11/2005)
[2] M. Benedict, E. Debowska, H. J. Jodl, L. Mathelitsch, R. Sporken, “Report and Recommendations on Available Multimedia Material for Teaching Optics at School and at University Level”, 8th Workshop on Multimedia in Physics Teaching and Learning of the European Physical Society – Proceedings, (Prague, Czech Republic 2003) http://lucy.troja.mff.cuni.cz/~tichy/MPTL/contributions/jodl/report_and_recommendations_for_teaching_optics_prag03.pdf (Accessed 9/11/2005)
[3] M. Benedict, E. Debowska, H. J. Jodl, L. Mathelitsch, R. Sporken, T. Bradfield, T. Colbert, L. Keiner, B. Mason, T. Meldor, S. Sen, J. Rauber, “Report and Recommendations on Available Multimedia Material for Teaching Mechanics at School and at University Level”, 9th Workshop on Multimedia in Physics Teaching and Learning of the European Physical Society – Proceedings, (Graz, Austria 2004) http://physik.uni-graz.at/MPTL9/proceedings/ProcSporkenMason.pdf (Accessed 9/11/2005)
[4] MERLOT is available online at http://www.merlot.org. More information about the project is available online at http://taste.merlot.org.
[5] S. Altherr, A. Wagner, B. Eckert, H. J. Jodl, „Multimedia material for teaching physics (search, evaluation and examples)", European Journal of Physics 25 (2004)
[6] Available online at http://taste.merlot.org/portal/physics/MERLOTPhysicsPeerReviews.htm

Appendix 1

List of links (EPS)

http://www.glue.umd.edu/~skumar/enme489c/Proj.html
http://lorax.chem.upenn.edu/Education/MB/MBjava.html
http://lorax.chem.upenn.edu/Education/MB/MBjava.html
http://www.colorado.edu/physics/2000/bec/temperature.html
http://jersey.uoregon.edu/vlab/Thermodynamics/therm1a.html
http://www.unidata.ucar.edu/staff/blynds/tmp.html
http://iva.uni-ulm.de/physik/vorlesung/THERMODYNAMIK/NODE48.HTML
http://www.mathematik.uni-ulm.de/phbf/phag/Waerme/waerme.html
http://www-tfp.physik.uni-karlsruhe.de/~didaktik/software/thermilab/thermilab.htm
http://homepages.compuserve.de/agaumann/a-praktikum/node49.html
http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/temper.html#c1
http://hyperphysics.phy-astr.gsu.edu/hbase/kinetic/ktcon.html#c1
http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/firlaw.html#c1
http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/seclaw.html#c1
http://www.uic.edu:80/~mansoori/Thermodynamics.Educational.Sites_html
http://www.deutsches-museum.de/mum/video/video09.htm
http://www.schulphysik.de/java/physlet/applets/brown.html
http://www.schulphysik.de/java/physlet/applets/maxwell.html
http://www.schulphysik.de/java/physlet/applets/druck1.html
http://didaktik.physik.uni-wuerzburg.de/~pkrahmer/ntnujava/idealGas/idealGas.html
http://www.k-wz.de/physik/gasgleichung.html
http://comp.uark.edu/~jgeabana/mol_dyn/KinThI.html
http://comp.uark.edu/~jgeabana/mol_dyn/physics.html
http://www.falstad.com/gas/
http://www.journey.sunysb.edu/ProjectJava/Lake/home.html
http://www.journey.sunysb.edu/ProjectJava/HPLab/home.html
http://www.chem.uci.edu/education/undergrad_pgm/applets/index.htm
http://www.chem.uci.edu/education/undergrad_pgm/applets/sim/simulation.htm
http://lorax.chem.upenn.edu/Education/java.html
http://www.ap.univie.ac.at/users/ves/grc2000/bx/
http://comp.uark.edu/~jgeabana/mol_dyn/KinThI.html
http://jersey.uoregon.edu/vlab/Piston/index.html
http://jersey.uoregon.edu/vlab/Balloon/index.html
http://comp.uark.edu/~jgeabana/mol_dyn/KinThI.html
http://www.phy.bme.hu/education/kinetic/index.html
http://www.almaden.ibm.com/vis/mol_dyn/mol_dyn.html
http://www.unidata.ucar.edu/staff/blynds/tmp.html
http://www.ebgymhollabrunn.ac.at/ipin/ph-hs123.htm
http://hex.desy.de/~holm/skriptSS2000/node31.html
http://www.universal-prinzip.de/kapitel6/kap6wissenschaft-3-8.htm
http://physicsnet.asn-graz.ac.at/versuche/langenausd.htm
http://www.asew.de/beratungszentrum/tipskwert.htm
http://www.its.caltech.edu/~atomic/snowcrystals/physics/physics.htm
http://www.elektronik-kompendium.de/sites/grd/0110201.htm
http://www.geocities.com/SiliconValley/Vista/6175/BTinstructions.html
http://www.phy.bme.hu/education/kinetic/index.html
http://comp.uark.edu/~jgeabana/mol_dyn/KinThI.html

http://www.chem.uci.edu/education/undergrad_pgm/applets/canonical/canonical.htm
http://www.geocities.com/SiliconValley/Vista/6175/brownian.html
http://www.math.utah.edu/~veronese/heat.html
http://www.oslo.sintef.no/NAM/people/gwz/java/heat.html
http://boojum.hut.fi/index.php3
http://www.uic.edu/~mansoori/TRL_html
http://members.tripod.com/~urila/index.htm
http://www.ikg.rt.bw.schule.de/fh/bec/bec.htm
http://members.tripod.com/~urila/colligative.htm
http://www.chem.uci.edu/education/undergrad_pgm/applets/bounce/bounce.htm
http://www.tu-bs.de/institute/pci/aggericke/PC1/Kap_III/Entropie.htm
http://poorcity.richcity.org/entrotom.htm
http://mysite.verizon.net/vzeoacw1/thermo.html
http://www.phy.ntnu.edu.tw/ntnujava/viewtopic.php?t=42
http://www.phy.ntnu.edu.tw/ntnujava/viewtopic.php?t=41
http://www.phy.ntnu.edu.tw/ntnujava/viewtopic.php?t=40
http://www.rawbw.com/~xmwang/myGUI/OttoG.html
http://www.augustana.edu/academ/physics/physlets/physletprob/ch8_problems/ch8_12_thermodynamics/thermodynamics8_12_3.html
http://cwx.prenhall.com/bookbind/pubbooks/giancoli3/chapter19/multiple3/deluxe-content.html
http://colos1.fri.uni-lj.si/~colos/COLOS/TUTORIALS/JAVA/THERMODYNAMICS/THERMO_UK/HTML/Pressure.html
http://webphysics.davidson.edu/faculty/jkk/physlets/html/thermodynamics_1.html
http://jersey.uoregon.edu/vlab/Thermodynamics/therm1a.html
http://jersey.uoregon.edu/vlab/Thermodynamics/therm1b.html
http://jersey.uoregon.edu/vlab/Thermodynamics/therm1c.html
http://jersey.uoregon.edu/vlab/Thermodynamics/therm1d.html
http://jersey.uoregon.edu/vlab/Thermodynamics/therm1e.html
http://jersey.uoregon.edu/vlab/Thermodynamics/therm1f.html
http://jersey.uoregon.edu/vlab/Thermodynamics/therm1g.html
http://chmtmc.aug.edu/ColbertWeb/phys1111/fall03/Assignments/physlets/contents/thermo/engine/illustration21_4.html
http://www.lefo.ro/fizica2/ising/intro.html
http://physics.ius.edu/~kyle/physlets/thermo/Otto.html
http://old.usgym.nl/kle/physengl/gaslaw.htm
http://home.eckerd.edu/~coxaj/physlet_talk/talk/CH01/ex20_6.html
http://www.lassp.cornell.edu/sethna/hysteresis/hysteresis.html
http://neon.chem.ox.ac.uk/vrchemistry/energy/
http://odin.prohosting.com/~evgenik1/wing.htm
http://jersey.uoregon.edu/vlab/Balloon/
http://chmtmc.aug.edu/ColbertWeb/phys1111/fall03/Assignments/physlets/contents/thermo/engine/illustration21_2.html
http://monet.physik.unibas.ch/~elmer/bm/
http://jersey.uoregon.edu/vlab/Thermodynamics/therm1b.html
http://jersey.uoregon.edu/Piston/
http://chmtmc.aug.edu/ColbertWeb/phys1111/fall03/Assignments/physlets/contents/thermo/engine/ex21_3.html
http://zebu.uoregon.edu/nsf/piston.html
http://chem.ps.uci.edu/education/undergrad_pgm/applets/bounce/bounce.htm

http://www.phy.ntnu.edu.tw/java/index.html
http://webphysics.davidson.edu/physletprob/ch8_problems/ch8_12_thermodynamics/default.html
http://www.chem.uci.edu/education/undergrad_pgm/applets/bounce/bounce.htm
http://eng.sdsu.edu/testcenter/javaapplets/planckRadiation/index.html
http://www.sc.ehu.es/sbweb/fisica/estadistica/termo/Termo.html
http://www.sc.ehu.es/sbweb/fisica/estadistica/termo1/termo1.html
http://jersey.uoregon.edu/vlab/index.html
http://www.umr.edu/~Egbert/BATTERY/Anibat.HTML
http://www.physik.uni-wuerzburg.de/physikonline/thermodynamik/thermodynamik.html (60 videos)
http://www.fernstudium-physik.de/medienserver/html/cgi/omsquery_cgi.exe?subject=Gase&subsubject=Kinetische+Gastheorie&type=&search=&query=Suche+starten%21
http://www.fernstudium-physik.de/medienserver/html/cgi/omsquery_cgi.exe?subject=Waermelehre&subsubject=&type=&search=&query=Suche+starten%21

Appendix 2

EPS and MERLOT Short List of Resources:

General Collections: Courses, texts, or broad collections of materials (7)

- http://www-tfp.physik.uni-karlsruhe.de/~didaktik/software/thermilab/thermilab.htm
- http://webphysics.davidson.edu/physletprob/ch8_problems/ch8_12_thermodynamics/default.html
- http://www.physik.uni-wuerzburg.de/physikonline/thermodynamik/thermodynamik.html
- http://www.fernstudium-physik.de/medienserver/html/cgi/omsquery_cgi.exe?subject=Waermelehre&subsubject=&type=&search=&query=Suche+starten%21
- http://www.unidata.ucar.edu/staff/blynds/tmp.html
- http://www.ap.univie.ac.at/users/ves/grc2000/bx/
- http://stp.clarku.edu/simulations/

Laws of Thermodynamics (3)

- http://home.eckerd.edu/~coxaj/physlet_talk/talk/CH01/ex20_6.html
- http://chem.ps.uci.edu/education/undergrad_pgm/applets/bounce/bounce.htm
- http://cwx.prenhall.com/bookbind/pubbooks/giancoli3/chapter19/multiple3/deluxe-content.html

Ideal Gas Processes (4)

- http://www.walter-fendt.de/ph14e/gaslaw.htm
  http://www.sc.ehu.es/sbweb/fisica/estadistica/termo1/termo1.html
- http://www.fernstudium-physik.de/medienserver/html/cgi/omsquery_cgi.exe?subject=Gase&subsubject=Kinetische+Gastheorie&type=&search=&query=Suche+starten%21
- http://mysite.verizon.net/vzeoacw1/thermo.html
- http://www.k-wz.de/physik/gasgleichung.html

Engines: Ideal gas engines (5)

- http://www.phy.ntnu.edu.tw/ntnujava/viewtopic.php?t=40
- http://www.rawbw.com/~xmwang/myGUI/CarnotG.html
- http://www.rawbw.com/~xmwang/myGUI/OttoG.html
- http://www.rawbw.com/~xmwang/myGUI/DieselG.html
- http://energy.sdsu.edu/testcenter/testhome/vtAnimations/index.html

Kinetic Theory: Velocity Distribution (6)

- http://jersey.uoregon.edu/vlab/Balloon/index.html
- http://intro.chem.okstate.edu/1314F00/Laboratory/GLP.htm
- http://comp.uark.edu/~jgeabana/mol_dyn/KinThI.html
- http://www.sc.ehu.es/sbweb/fisica/estadistica/maxwell/maxwell.html
- http://www.falstad.com/gas/
- http://lorax.chem.upenn.edu/Education/MB/MBjava.html

Kinetic Theory: Pressure, Temperature, Diffusion, and Equilibrium (6)

- http://jersey.uoregon.edu/vlab/Thermodynamics/index.html
- http://www.sc.ehu.es/sbweb/fisica/transporte/brownian/sedimentacion.htm
- http://curie.umd.umich.edu/Physlets/osmosis.html
- http://www.schulphysik.de/java/physlet/applets/druck1.html
- http://colos1.fri.uni-lj.si/~colos/COLOS/TUTORIALS/JAVA/THERMODYNAMICS/THERMO_UK/HTML/Pressure.html
- http://www.phy.ntnu.edu.tw/ntnujava/viewtopic.php?t=42

Kinetic Theory: Brownian Motion (5)

- http://www.phy.ntnu.edu/~hwang/gas2D/gas2D.html
- http://galileo.phys.virginia.edu/classes/109N/more_stuff/Applets/brownian/brownian.html
- http://monet.physik.unibas.ch/~elmer/bm/
- http://www.deutsches-museum.de/mum/video/video09.htm
- http://www.schulphysik.de/java/physlet/applets/brown.html

Stat Mech: Energy levels and Boltzmann distribution (2)

- http://www.sc.ehu.es/sbweb/fisica/estadistica/niveles/niveles.html
- http://ir.chem.cmu.edu/irproject/applets/statmech/Applet.asp

Heat Diffusion (3)

- http://orange.math.buffalo.edu/437/laplace/
- http://www.glue.umd.edu/~skumar/enme489c/Proj.html
- http://www.sc.ehu.es/sbweb/fisica/transporte/conduccion/conduccion.htm#Solucion%20analitica

Radiation (6)

- http://www.micro.magnet.fsu.edu/primer/java/colortemperature/index.html
- http://webphysics.davidson.edu/Applets/BlackBody/BlackBody.html
- http://zebu.uoregon.edu/nsf/planck.html
- http://csep10.phys.utk.edu/guidry/java/wien/wien.html
- http://csep10.phys.utk.edu/guidry/java/planck/planck.html
- http://www.sc.ehu.es/sbweb/fisica/cuantica/negro/radiacion/radiacion.htm

Quantum Statistics: Fermi statistics (4)

- http://jas.eng.buffalo.edu/education/semicon/fermi/functionAndStates/functionAndStates.html
- http://jas.eng.buffalo.edu/education/semicon/fermi/levelAndDOS/index.html
- http://jas2.eng.buffalo.edu/applets/education/semicon/fermi/bandAndLevel/fermi.html
- http://jas.eng.buffalo.edu/education/semicon/fermi/heavyVSmoderate/

Materials Properties: Magnetism, Dielectrics, etc. (3)

- http://www.sc.ehu.es/sbweb/fisica/elecmagnet/ferromagnetismo/ferromagnetismo.htm
- http://www.sc.ehu.es/sbweb/fisica/elecmagnet/dielectricos/dielectrico.htm
- http://www.sc.ehu.es/sbweb/fisica/elecmagnet/paramagneticos/paramagnetico.htm#Descripcion

Appendix 3

List of EPS Criteria

Title:	
Author:	
Topic:	
URL:	

			Rating*	Comments
motivation	User-friendliness	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?		
	Attractiveness:	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?		
	Clear description of purpose and work assignment:	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?		
content	Relevance	Is the topic important?		
		Does it make sense to use the MM (e.g. problems in understanding, dynamic process)?		
	Scope	Is there a profoundness of content?		
		Is there a broadness of content (special case, general overview)?		
	Correctness	Is the content of the MM correct?		
		Are simplifications indicated?		
method	Flexibility	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?		
	Matching to target group	Is a reasonable didactical reduction implemented?		
		Are technical terms explained?		
		Are the objectives appropriate?		
	Realization	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)?		
	Documentation	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?		

Appendix 4

EPS evaluation forms of recommended (Excellent and some Very Good) material

Title:	The Expert System for Thermodynamics (TEST)			
Author:	prof. S. Bhattacharjee, San Diego State University			
Topic:	Ideal gas and engines			
URL:	http://energy.sdsu.edu/testcenter/			
			Rating	Comments
motivation	User-friendliness	Is it easy to start using the MM?	++	Using of the page needs a registration but it is easy to receive access mode from the author
		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?	++	
	Attractiveness:	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?	+	
	Clear description of purpose and work assignment:	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?	++	
content	Relevance	Is the topic important?	++	
		Does it make sense to use the MM (e.g. problems in understanding, dynamic process)?	++	
	Scope	Is there a profoundness of content?	++	
		Is there a broadness of content (special case, general overview)?	++	
	Correctness	Is the content of the MM correct?	++	
		Are simplifications indicated?	++	
method	Flexibility	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?	++	
	Matching to target group	Is a reasonable didactical reduction implemented?	++	It is addressed to students, educators and professionals
		Are technical terms explained?	+	
		Are the objectives appropriate?	++	
	Realisation	Is the general approach suitable to present the subject and realise aims of the given MM?	0	
		Is the type of MM chosen reasonable (video, simulation, animation)?	+	
	Documentation	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?	++	

Title:	Java Simulations for Statistical and Thermal Physics
Author:	Harvey Gould, Jan Tobochnik +a team of authors
Topic:	Statistical physics
URL:	http://stp.clarku.edu/simulations/

			Rating	Comments
motivation	User-friendliness	Is it easy to start using the MM?	++	
		Are the design comprehensible and the image quality satisfactory?	0	
		Is the function of control elements evident?	+	
		Are the software requirements clear and of adequate proportion?	++	
	Attractiveness:	Is the layout appealing?	0	
		Is there a motivating introduction?	0	
		Are there interactive components?	++	
		Is the topic interesting (reference to everyday life, applications, explaining a phenomenon)?	0	
		Is the MM up-to-date / innovative?	+	
	Clear description of purpose and work assignment:	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?	0	
content	Relevance	Is the topic important?	++	MM is ideally suited to make stat.phys understandable
		Does it make sense to use the MM (e.g. problems in understanding, dynamic process)?	++	
	Scope	Is there a profoundness of content?	++	The content is broad 23 different applets
		Is there a broadness of content (special case, general overview)?	++	
	Correctness	Is the content of the MM correct?	++	The simplifications are thought to be self evident by the authors, and are not explained
		Are simplifications indicated?	0	
method	Flexibility	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?	0	
		Does the MM allow for the same topic to be approached in different ways?	-	
	Matching to target group	Is a reasonable didactical reduction implemented?	++	Only part of the simulations contains a description the student needs.
		Are technical terms explained?	--	
		Are the objectives appropriate?	0	
	Realisation	Is the general approach suitable to present the subject and realise aims of the given MM?	++	
		Is the type of MM chosen reasonable (video, simulation, animation)?	++	
	Documentation	Is the operation obvious or explained?	0	http://stp.clarku.edu/notes/ Lecture notes associated to the project, but no reference it is made to it on the simulation pages
		Is the material self-evident or explained by additional text?	0	
		Is there a reference to material for further studies?	0	
		Are there any suggestions for implementation into the teaching process?	--	

Title:	***Charge Carriers and Fermi Level*** [Semiconductor Statistics]			
Author:	C.R.Wie, SUNY-Buffalo			
Topic:	Quantum Statistics: Fermi statistics			
URL:	http://jas.eng.buffalo.edu/			

			Rating	Comments
motivation	User-friendliness	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?	++	
	Attractiveness:	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?	+	
	Clear description of purpose and work assignment:	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?	++	
content	Relevance	Is the topic important?	++	
		Does it make sense to use the MM (e.g. problems in understanding, dynamic process)?	+	
	Scope	Is there a profoundness of content?	++	
		Is there a broadness of content (special case, general overview)?	++	
	Correctness	Is the content of the MM correct?	+	Some improvements were announced in 1998, but not implemented.
		Are simplifications indicated?	++	
method	Flexibility	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?	0	
	Matching to target group	Is a reasonable didactical reduction implemented?	+	
		Are technical terms explained?	+	
		Are the objectives appropriate?	++	
	Realisation	Is the general approach suitable to present the subject and realise aims of the given MM?	++	
		Is the type of MM chosen reasonable (video, simulation, animation)?	++	
	Documentation	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?	+	

Title:	Black Body Radiation
Author:	Angel Franco Garcia
Topic:	Black Body Radiation
URL:	http://www.sc.ehu.es/sbweb/fisica/cuantica/negro/radiacion/radiacion.htm

			Rating	Comments
motivation	User-friendliness	Is it easy to start using the MM?	+	in spanish
		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?	+	browser (Firefox) crashes sometimes
	Attractiveness:	Is the layout appealing?	0	
		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?	+	
	Clear description of purpose and work assignment:	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?	+	
content	Relevance	Is the topic important?	++	
		Does it make sense to use the MM (e.g. problems in understanding, dynamic process)?	+	
	Scope	Is there a profoundness of content?	++	
		Is there a broadness of content (special case, general overview)?	++	
	Correctness	Is the content of the MM correct?	+	
		Are simplifications indicated?	+	
method	Flexibility	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?	0	
		Does the MM allow for the same topic to be approached in different ways?	0	
	Matching to target group	Is a reasonable didactical reduction implemented?	+	
		Are technical terms explained?	++	
		Are the objectives appropriate?	++	
	Realisation	Is the general approach suitable to present the subject and realise aims of the given MM?	+	
		Is the type of MM chosen reasonable (video, simulation, animation)?	+	
	Documentation	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?	0	