Response to Draft National Curriculum

May 2012

Scientific Errors

- **Incorrect use of the term "accuracy"** (The ultimate references in this respect are the "Guide to the expression of uncertainty in measurement" (GUM) and the "International vocabulary of metrology" (VIM). These documents are both available free at the BIPM website at the URLs http://www.bipm.org/en/publications/guides/gum.html and http://www.bipm.org/en/publications/guides/vim.html, respectively.)
  - **Organisation document page 6:** The draft states "students are required to make measurements with an appropriate degree of accuracy and to represent measurements using appropriate units, and, as appropriate, to specify confidence intervals to indicate accuracy."

    The phrase "an appropriate degree of accuracy" is unclear. It seems to indicate that accuracy is a quantity that can be specified numerically. This interpretation of this statement is supported by the final part of the sentence.

    The use of the word "accuracy", at the end of the sentence, is incorrect. It should be "precision". "Confidence intervals" indicate precision, not accuracy. In addition, the use of the term "confidence intervals" is out of place; this is the only time it is used in the document. In relation to measurements in physics the term "uncertainties" is more appropriate. The sentence could be rewritten along the lines: "students are required to make measurements with appropriate accuracy and precision, report experimental results with appropriate units and, when asked, specify their precision through the use of uncertainties."
  - **Curriculum document pages 5, 14, 24, 32 dot point 4:** The draft states "including the use of appropriate SI units and symbols to indicate the accuracy of individual and multiple measurements". However, the use of any particular units or symbols (SI or otherwise) have nothing to do with indicating accuracy. This last part of the sentence (from "to indicate" to the end) simply needs to be removed.
  - **Curriculum document page 33 second to last dot point on the page**: Both uses of the term "accuracy" should be replaced by "precision". The Heisenberg uncertainty relation relates to the standard deviation of the spread of multiple measurements that one gets… hence, "precision".

- **Incorrect terms in the equation for calculating radiation exposure (curriculum document, page 10)**: "{*dose equivalent*} = {*quality factor*} × {*absorbed dose*}" it should be "{*equivalent* dose} = {*radiation weighting factor*} × {*absorbed dose*}" i.e. the term dose equivalent must be replaced by the term "equivalent dose" and the term "quality factor" must be replaced by the term "radiation weighting factor".

  The change was introduced way back in 1990 by the International Commission on Radiological Protection in ICRP Publication 60. Unfortunately one has to pay for this publication. However, the definitive Australian reference, Radiation Protection Series 1, (which references ICRP Publication 60) is free. There is also a nice simple government web page available. Using the correct terms will also make it easier for students to find information relevant to nuclear radiation e.g. if one googles "quality factor" one gets lots of links about resonance, whereas if one googles "radiation weighting factor" one gets many useful radiation related references. (ICRP Publication 60 has been superseded, but this has not involved further changes to the names of the terms discussed here.)

- **Incorrect use of the term "thermal energy" and related points (curriculum document, page 6).**
  - **First dot point:** "Thermal energy can be transferred between and within systems". This is an incorrect use of the term "thermal energy". Thermal energy is a state variable of a system. It is "heat" that is transferred. This is a similar mistake to confusing the terms "potential energy" and "work".
  - **Third dot point**: "internal thermal energy" is a tautology; there is no need for the term "internal".
  - **Fourth dot point:** while this is true for a monatomic ideal gas, considering the previous dot point has mentioned more general concepts of motion (e.g. vibration… and should also mention rotation) this dot point needs revision. Especially as these concepts relate to differences in heat capacities (due to degrees of freedom) and the students study heat capacities.
  - **Last dot point:** Needs to be reworded due to misuse of the term "thermal energy" similar to the first dot point.

  References (a range of textbooks to hand):

  - Shcroeder, D 2000, *An Introduction to Thermal Physics*, Addison Wesley Longman, pp. 15-18
  - Knight, R 2008, *Physics for Scientists and Engineers*, 2nd edn, Pearson Addison-Wesley, San Francisco, p. 515

- Halliday, D, Resnick, R, Walker, J 2005, *Fundamentals of Physics*, John Wiley & Sons, Inc. NJ, p.484
- Giancoli, D 2005, *Physics*, 6th edn, Pearson Prentice Hall, NJ, p.386
- Serway, R, Jewett, J 2004, *Physics for Scientists and Engineers*, 6th edn, Thomson, p. 605
- Cutnell & Johnson 2009, Physics, 8th edn, John Wiley & Sons, Inc. NJ, p.369
- + at least another 4 (Fishbane et al, Young & Freedman, Alonso & Finn, Giambattista et al)… but I grow tired of this :-)

As they should, all the above references clearly distinguish between "internal energy" as a state variable and "heat" as the energy transfer between systems. In addition, the majority of the references above (except Giancoli which uses internal energy = thermal energy and Cutnell & Johnson which doesn't use the term "thermal energy") use the term "thermal energy" as that part of the internal energy that relates to temperature as opposed to phase changes. To be fair, I found one textbook (Cummings et al, Understanding Physics) that uses the term "thermal energy" to talk about the state of a system and "thermal energy transfer" instead of heat. (Pity the students who use this textbook!)

At this level, the importance of the correct use of the term "Work" is emphasized. Students should equivalently correctly use the term "heat". This is particularly important in terms of the equation $\Delta U = Q + W$ (or $-W$, depending on convention); where it is important to distinguish between "internal energy" (U), "heat" (Q) and "work" (W).

- **Incorrect units for G (page 27 & page 28 multiple locations)**: The units should be N m^2 kg^{-2}. In the text the minus sign is missing from the exponent for "kg".
- **Incorrect formula for uncertainty relationships (page 37):** for both uncertainty formulas the right hand side should be either $h/4\pi$ or $\hbar/2$.
- **Error in the definition of "evidence" (Glossary, page 2)**: In the Glossary it states "In science, evidence is data that is considered reliable and valid and which can be used to support a particular idea, conclusion or decision. Evidence gives weight or value to data by considering its credibility, acceptance, bias, status, appropriateness and reasonableness."

  The draft ties itself in definitional knots. First it states that "evidence is data that is considered reliable and valid" and then it states that "evidence gives weight or value to data" i.e. it is not data, but something that supports data! The second sentence adds nothing, says nothing, and can simply be scrapped. Or could be replaced by something like: "Evidence provides support for the acceptance of a particular scientific model." I would also change the first sentence to "valid and reliable" from reliable and valid". This is the way around it is in the rest of the document.

Spelling and Grammatical Mistakes

- **Organisation document, page 6, first sentence of first paragraph:** has the word "contnues" which should be "continues".
- **Organisation document, page 7, first sentence of fifth paragraph**: has "other others' ". The first "other" needs to be deleted.
- **Curriculum document page 32, dot point 5:** it should be "level diagrams" instead of "level diagram".

Suggestions for other local changes

- **Inconsistent/poor use of the terms "valid and reliable" and "accurate and precise" (Page 5, 14 & 24 dot point 3)**. The "Organisation" document aptly refers to the requirement for "valid and reliable collection of data" and the Aims section at the beginning of the Curriculum document appropriately mentions a "commitment to accurate and precise measurement". In both cases the terms naturally go together as being at the "same level" of definition ("valid and reliable" more vague and broad, "accurate and precise" tightly defined and specific). However, at these locations the document mixes this up and uses "accurate and reliable". I would suggest replacing "accurate and reliable" with "valid and reliable" or "accurate and precise".
- **Use of the term "accuracy" other than for "measurement accuracy"**. Given that the term "accuracy has a very specific meaning in physics but is frequently abused due to its application outside of physics (similar to the term "work") this has the potential to cause confusion. Hence the following changes are suggested:
    - **(Page 20)** "Physics Inquiry Skills" dot point 3 in both achievement A and B "represents data accurately" change to "represents data appropriately".
    - **(Page 20 & 21 "Physics Inquiry Skills" dot point 6 in achievements A, B and C**) "communicates clearly and accurately" change to just "communicates clearly" simply drop the "and accurately".
    - **(Page 25 "Science as a Human Endeavour" second dot point)** "The accurate prediction of…" the word "accurate' is not needed here and even the word "prediction" is a bit confusing as one of the examples given is "forensic

ballistics" which is not about prediction but about after-the-fact modelling. The sentence could start with "The modelling of…"

- **Page 38 "Physics Inquiry Skills" dot point 3 in both achievement A and B** "represents data accurately" change to "represents data appropriately".
- **Page 38 & 39 "Physics Inquiry Skills" dot point 6 in achievements A, B and C** "communicates clearly and accurately" change to just "communicates clearly" simply drop the "and accurately".

- **The draft defines/redefines terms (electric and magnetic constant) potentially leading to confusion; and missing an opportunity for links to other parts of the curriculum (Page 28)**: The terms "electric constant" and "magnetic constant" are here used in non-standard way that has the potential to confuse both teachers and students. I cannot find a textbook with the terms used in this way and if one googles these terms one gets them defined as ε_0 and μ_0. In addition the electric constant K_e (represented anywhere else as a small *k* e.g. k_e) is widely referred to (in textbooks or if one googles the term) as the "electrostatic constant" or "Coulomb's constant", if given a name at all.

  In addition, the electrostatic constant K_e is more usually represented as a small *k* rather than a capital e.g. k_e. Also, I have not seen the "magnetic constant" bundled into one term (K_m) anywhere else. I would advocate removing the deliberate avoidance of reference to ε_0 and μ_0. If the terms were mentioned here it would be useful to link to later on in discussions of relativity ($c = 1/\sqrt{\varepsilon_0\mu_0}$) and good for students to have heard of, even if they do not yet completely understand their use or significance.

- **A potentially strange statement about special relativity (page 33, dot point 1):** I am not immediately convinced that the second part of this dot point naturally follows from the first, as claimed in the dot point… happy to be corrected… but whichever it is I believe the purpose of this dot point is obscure. It seems to be a very roundabout way of saying $E = mc^2$ with a potentially obscure/unhelpful justification.

- **A misleading statement about an application of relativity (page 33, dot point 4):** The draft states "Applications of special relativity include GPS tracking…" However, GPS is not an application of special relativity; in the sense that no one said "Ah… special relativity… now we can do GPS!" but rather something more along the lines of "…the effects of SR have to be taken into account for GPS to work as precisely as it does."

- **Planck, Bohr and Einstein are misleading choices for a list of people responsible for the photon model (top of page 34):** Planck and Bohr, in their separate ways, were actively against a particulate model for light. It would be more appropriate to have Einstein and Compton mentioned.

- **Poor definition of "Experimental (investigation)" (Glossary, page 2)**: "Experimental (investigation) - An investigation that involves carrying out a practical activity." This is surely defining one term using another undefined term? I would suggest something along the lines of "Experimental (investigation) - An investigation that involves using apparatus to make measurements of physical quantities."

Comments on the organisation of the Curriculum

- I would swap Units 1 & 2. I believe one should talk about motion and kinetic energy before one can talk about the kinetic model related to temperature, or the kinetic energy carried away by the constituents of radioactive decay etc. and an understanding of waves and light is useful before gamma rays are discussed.
- As an observation, rather than commenting on the impact. It is strange to go from an attempted draft (the previous draft curriculum) which contained a significant Astronomy component, to one that contains almost no Astronomy. Has Astronomy, a potential drawcard, been missed out?
- There is now also no Materials, and little on Medical physics. Are these omissions deliberate and reasoned? In general, the applications side of physics seems to be missing… is this a deliberate design decision allowing the states to meet the broad strokes of the curriculum through (potentially local e.g. Synchrotron, SKA) applications?