Examiner's Report 2006. S8: Covariant Electromagnetism

This paper was taken by 11 physicists and (as BT2) 13 P&P students. One P&P candidate made only a token attempt at one question (obtaining 3 marks), and their results are omitted in the statistics given below.

The overall level of the paper seemed to be satisfactory.

S8 All Candidates

N	23
Mean	34.9
Standard Deviation	9.6
Maximum	48
Minimum	17

There was a significant difference between physics and P&P candidates.

S8 Physics Candidates

N	11
Mean	39.2
Standard Deviation	8.2
Maximum	48
Minimum	27

S8 P&P Candidates

N	12
Mean	31.0
Standard Deviation	9.3
Maximum	46
Minimum	17

The mean for physics candidates is quite high, and I think this genuinely reflects the strength of the candidates taking the paper. All four questions involved significant engagement with the fairly theoretical syllabus, and a significant number of physics candidates obtained very high marks. Bearing in mind that this paper is optional for physicists, it seems likely that there is pre-selection of strong candidates. The mean for physics and philosophy is in a very sensible place.

The printed mark scheme was used in all cases, and the average marks on all four questions were extremely similar. Thus the results indicate a well-balanced paper.

S8 Question 1

N	10
Mean	17.6
Standard Deviation	5.4
Maximum	25
Minimum	8

Question 1 was the first time that the material on units in electromagnetism had appeared on the paper. The question was closely based on material in the lecture notes. The final part, on the relative size of the charge unit in Heaviside and SI units, was frequently misread: many candidates gave the number of multiples of the Heaviside unit required to make the Coulomb, which is obviously the reciprocal of what was asked. Credit was given in all cases where the symbols used were defined with adequate clarity.

S8 Question 2

N	17
Mean	17.1
Standard Deviation	6.1
Maximum	25
Minimum	4

This was a straightforward question involving the transfrmation of the potential from one frame to another followed by extraction of the fields in the new frame. Most candidates noted that it was necessary to transform the functional dependence to the new coordinates even though it was in this case trivial ($x' = x$, $y' = y$), and marks were awarded for this observation. Curiously, several candidates tried to transform the charge per unit length as a four-vector even though the question explicitly stated that it was not a part of a four-vector, doubtless encouraged by the fact that for this particular transformation it did in fact give the correct answer. However this was not deemed an answer to the question.

S8 Question 3

N	12
Mean	17.6
Standard Deviation	5.3
Maximum	25
Minimum	9

Question 3 on the transformation of the field tensor was shortened during the setting process to reduce the amount of algebra, and the result was a fairly straightforward question on the principles of transforming a second-rank tensor without actually carrying out the matrix multiplication. The final 10 marks were available for manipulation of a given expression, and this was one point where the difference between physics and P&P candidates was clearly apparent: virtually all the physics candidates got all 10 marks, and hardly any P&P candidates. There were three points of difficulty in the manipulation: rearranging scalar triple products, expanding the square of a cross product, and the relation $\gamma^2 - \gamma^2\beta^2 = 1$, and all of these caused difficulty for P&P candidates.

S8 Question 4

N	7
Mean	16.9
Standard Deviation	7.1
Maximum	25
Minimum	7

The final question was on gauge transformation of wavefunctions and potentials, and the gauge-invariant current. This was the other point at which P&P candidates did much less well than the physicists: the question was only attempted by 3 physicists, who understood the material and got very high marks, and by 4 P&Ps, who on the whole didn't, and this mark distribution produced the largest standard deviation.