Department of Physics & Astronomy
Module Report
Semester 1, 2014-15

Course Title: Particle Physics
Module: PHY304
Lecturer(s): Chris Booth
Number of students: 84

General Comments: There were no major changes to the course this year. The printed course booklet was again produced, instead of using separate handouts for each topic. The expanded topic of quark symmetry in baryons was continued. There were 21 lectures plus two revision & problem classes, one just before the exam. Five assessed homeworks were set fortnightly, with unassessed problem sheets in the intervening weeks. The use of a feedback sheet for each homework, discussing common problems and errors, was continued. There was a slight change to the weighting of exam questions, with the compulsory question being out of 20 and the others out of 15.

Problems Experienced: None.

Coursework Performance: (5 homeworks) This was generally performed well. Students appeared to appreciate that it gave them practice in kinematic calculations, in particular. Most students attempted all questions, though one handed in no homeworks, two did only 1 or 2 of the 5 and another 8 omitted 1 or 2 homeworks. Several students handed work in late and were penalised. The average mark overall was good, at 74.4%.

Exam Performance:
Exam performance was similar to previous years'. The main weaknesses displayed were inadequate explanations (mentioning a few facts without explaining any connections) and faulty logical reasoning, e.g. in explaining the relationship between observations and theories.

Question 1 (compulsory) – most sections were generally well answered. Many defined leptons simply as "fundamental fermions" (which would include quarks). Most ignored the question on scale invariance. Some drew Feynman diagrams for muon decay which did not conserve charge or lepton number. The question on Cabibbo theory was poorly answered, with inadequate explanation. The kinematics question was done well. Many said the propagator depended on "mass", without specifying mass of what! Average 13.0 out of 20 (65%).

Question 2 (form factors) – a popular question. Some good answers. The standard derivation was done well, though with inadequate explanation, but many people could not cope with the integrals or used the wrong limits. Several people spent a long time on an unnecessary normalisation calculation. Average 8.7/15 (58%) for 62 attempts.

Question 3 (generations and evidence for only 3, kinematics) – a less popular question, but some excellent answers. Most gave the particle content of the standard model correctly. The reason that the evidence indicates 3 generations was frequently poorly described, and the reasons for needing high energy not given clearly. In the kinematic calculation, unjustified assumptions about angles were often made, or it was assumed that the scalar sum of momenta was conserved. Average 8.6/15 (57%) for 43 answers.

Question 4 (gauge invariance, parity and neutrinos, allowed interactions) – a reasonably popular question. However, most people ignored the first part of the question, and explanations of parity and charge conjugation were of variable quality. Recognition of which reactions were caused by which interaction was generally good, but explanations could have been better. Average 6.7/15 (45%) for 49 answers.

Question 5 (Exchange interactions, quark symmetry, kinematics) – An unpopular question which was not done well. Many people did not give the properties of the exchanged bosons (spin, mass etc) as requested but instead talked about conserved quantum numbers in the reactions. Symmetry of hadrons was confused with that of the constituent quarks. The kinematic calculation was done very badly (despite its similarity to a homework!) Average 7.2/15 (48%) for 23 answers.

Overall average 57.7% on exam, 60.2% including homeworks; 9 students failed; 26 first class marks.

Answers to numerical and similar questions

1d) Σ^- = s d d; Δ^- = d d d

1e) Weak interaction (change in strangeness).

1h) Pion energy is 748 MeV.

2c) $F(q) = 2\pi A \frac{\frac{\pi\hbar}{qR}\sin\frac{qR}{\hbar} - 2}{\left(\frac{\pi}{2R}\right)^2 - \left(\frac{q}{\hbar}\right)^2}$.

3c) Mass is 0.1396 GeV/c^2.

4c)i) Forbidden – violation of muon lepton number.

4c)ii) Weak – involvement of neutrinos.

4c)iii) Weak – change of strangeness by 1 unit.

4c)iv) Forbidden – change of strangeness by 3 units.

4c)v) Strong – hadrons involved, all QN conserved.

4c)vi) Electromagnetic (electroweak at high energy) – charged leptons involved.

4c)vii) Strong – all QN conserved.

4c)viii) Forbidden – change of strangeness (and hadron collision, not decay).

5c) Lightest state p π^0 e; minimum electron energy 145 MeV/*c*.

Planned Revisions for next session: Minor changes to structure of homeworks.

Course work deadlines and return of marked work

All work was handed out and required on the dates indicated at the start of the semester on the Third Year timetable. Each piece of work was returned with comments one week after being handed in.

Feedback was provided by comments written on the marked scripts, a specimen solution for each question and a "feedback sheet" containing comments on common errors, easier approaches etc.

Work	Given out	Handed in	Returned to students
Homework 1	30th Sep.	7th Oct.	14th Oct.
Homework 2	14th Oct.	21st Oct.	28th Oct.
Homework 3	28th Oct.	4th Nov.	18th Nov.
Homework 4	18th Nov.	25th Nov.	2nd Dec.
Homework 5	2nd Dec.	9th Dec.	16th Dec.

C N Booth
26th January 2015