# Department of Physics & Astronomy
# Module Report
# Semester 1, 2013-14

Course Title: Particle Physics
Module: PHY304
Lecturer(s): Chris Booth
Number of students: 98

General Comments: This year, an expanded printed course booklet was produced, instead of using separate handouts for each topic. An extra topic of quark symmetry in baryons was introduced. There were 20 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.

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 and one did only 2 of the 5. The average mark overall was good, at 74.6%.

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. Most defined baryons & mesons correctly, with correct examples, though for differences several people just repeated the quark content or rather tautologously said "baryons have baryon number" without saying this was a conserved quantity. The Feynman diagram was mainly correct, though several had quarks and leptons fusing. The kinematic calculation was usually correct, though several drew different "lab and c of m" diagrams, even though the muon was at rest. Definitions of virtual particles were often imprecise, and statements like "time-like photons have zero momentum" could obviously only be true in a specific frame of reference. The explanation for the strong q.n. being called colour often featured irrelevant discourses on the exclusion principle! Average 7.0.

Question 2 (form factors) – not very popular. Some perfect answers, but many only got the first, bookwork sections correct. A surprising number ignored the charge distribution of the question and reproduced homework solutions (for no marks!). Others integrated over $r$ instead of volume to attempt the normalisation. Average 5.1 for 39 attempts.

Question 3 (quantum numbers, symmetry, kinematics) –a very popular question. Explanations of isospin were poor. Most drew the meson octet correctly, though not all listed quantities like isospin, as required. Most people discussed total symmetry, rather than flavour symmetry. Almost everyone did the kinematic calculation correctly. Average 6.0 for 88 answers.

Question 4 (quark charges, weak interaction, allowed interactions) – another popular question. However, explanations for the first two parts were very poor – little detail was given, theory and experimental evidence were confused, and the significance of the observations was not stated. Recognition of which reactions were caused by which interaction was generally very good. Average 5.0 for 60 answers.

Question 5 (Invariance, parity, kinematics) – A very unpopular question. Explanations of invariance under a translation were sketchy, and the parity calculation was not generally done well (despite its similarity to a homework!) Average 4.1 for 5 answers.

**Overall** average 59.6% on exam, 62.2% including homeworks; 6 students failed; 33 first class marks.

Answers to numerical and similar questions

1e) Electron energy is 52.9 MeV.

1i) Weak interaction (change in strangeness).

2c)i) $A = \dfrac{3}{\pi R^3}$.

2c)ii) $\mathrm{F}(\underline{q}) = \dfrac{12\hbar^3}{q^3R^3}\left(2\dfrac{\hbar}{qR}\left(1-\cos\dfrac{qR}{\hbar}\right)-\sin\dfrac{qR}{\hbar}\right)$.

3c)i) u d d.

3c)ii) $\dfrac{1}{\sqrt{3}}(\mathrm{udd}+\mathrm{dud}+\mathrm{ddu})$.

3d) Positron energy 581 GeV.

4c)i) Weak – involves neutrinos.

4c)ii) Forbidden – violation of tau lepton number.

4c)iii) Strong – hadrons, all quantum numbers conserved.

4c)iv) Forbidden – change of strangeness by 2 units.

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

4c)vi) Electromagnetic – involves photons, all quantum numbers conserved.

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

4c)viii) Strong – hadrons, all quantum numbers conserved.

5b) Parity of meson is –1.

5c) Kaon momentum 142.8 meV/*c*.

Planned Revisions for next session: Students have suggested additions to the course booklet, which I intend to implement.

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 | 1st Oct. | 8th Oct. | 15th Oct. |
| Homework 2 | 15th Oct. | 22nd Oct. | 29th Oct. |
| Homework 3 | 29th Oct. | 5th Nov. | 19th Nov. |
| Homework 4 | 19th Nov. | 26th Nov. | 3rd Dec. |
| Homework 5 | 3rd Dec. | 10th Dec. | 17th Dec. |

C N Booth
29th January 2014