Phys2006 Classical Mechanics June 2017

This year's exam produced some very tangled answers that were illogically laid out with little commentary, resembling collages of half-remembered snippets rather than coherent, rigorous, logical progressions. There were surprising deficiencies in basic mathematics: vector notation was rarely adopted consistently (if at all) even when necessary, and few students seemed confident with vector products, while differentiation of products and functions befuddled most students, and many could not set up definite integrals. A number of students, seeing questions on topics familiar from school, reverted to GCSE-level approaches that were sadly inadequate for this second year university course. Handwriting and diagram-drawing seemed to have deteriorated greatly since last year, and in too many cases would have disappointed a primary school teacher.

Students were a little better than last year at unpacking questions, and more persevered to the end. The course material seemed to have been understood and learned, but could not be so reliably applied, and many scripts indicated inadequate synthesis of material into understanding. Very few students ran out of time, and several attempted three questions from the B-section.

The mean exam mark was 49.5%. For the 117 who sat the exam, the mean overall mark was 54.7%, while 17 failed the course.

Section A **mean 9.5/20**

Answers this year were often very sparse and vague. Some students really grasped the concepts and wrote down their working and thoughts, but too many did not, and lost both marks and a clear understanding of what they were doing. Many found it difficult to apply their knowledge to questions that were only slightly different from those they had previously met.

A1 Vector rotation **mean 2.0/4**

While there were some good solutions to this derivation of a core result, many students were confused because they attempted to answer without drawing an adequate diagram and/or adopting vector notation. A common problem was not considering properly what was given in the question, and many were unable to construct a rigorous argument to demonstrate their understanding.

A2 Kepler's laws **mean 3.1/4**

This question was generally answered well: students were able to recount Kepler's laws, often as more or less textbook responses, which was good to see. They were less aware of the assumptions governing these laws however, but many made a good stab and usually wrote down something sensible.

A3 Gravity for a spherically-symmetrical distribution **mean 1.2/4**

This question stumped many students, who were mostly undone by difficulties with vectors and 2-D definite integrals. About half knew Gauss's law in its original form, but only a handful were able to get it into a useful format. Those who attempted direct integration were often unable to break it down into an integral in the first place. Many students wrote vague, confused and often incorrect answers about how the mass distribution at a distance was the same as for a point mass in a form akin to that of a charged particle.

A4 Moment of inertia **mean 1.7/4**

Given the time devoted to moments of inertia in our exercise sheets, it was worrying that students were unsure how to attempt this question. Many tried to use some form of spherical symmetry as in other examples. The definition of the sides of the square was often confused, leading to numerical errors in the direct integration method. The perpendicular axis theorem was mostly understood but incorrectly applied, with students equating the moments of inertia about all three principal axes and fudging the results given.

A5 Coriolis deflection **mean 1.5/4**

This resembled an exercise sheet question in which the bullet is fired east instead of west, and a large minority of students gave the earlier answer from memory. Those who worked it out fully commonly gave only vague explanations of the deflection; far too many gave answers such as "left and down" with no explanation. Many students ignored either the Coriolis or centrifugal force or argued incorrectly that they had no effect.

Section B **mean 20.3/40**

B1 The Bricklayer's Lament **38 attempts** **mean 9.4**

Some clarity of thought was required for this simple question, which hence challenged those who elected not to begin with a proper diagram. There was a marked reluctance to set out solutions methodically, define terms and state assumptions. Many students failed to show their working, or inserted numerical values instead of keeping their analysis in algebraic form, which lost them marks when their calculations went wrong. Many forgot that while one object was descending, the other was ascending. Several forgot that tension is a force rather than an acceleration, a vector rather than a scalar, or expressed weights in kg. A surprisingly number could not multiply by 100.

B2 Coupled pendula **42 attempts** **mean 10.2**

This question seemed to appeal to those fond of matrix mathematics: despite a few excellent and innovative solutions, there were some very poor definitions of SHM in (a) and derivations of the corresponding equation in (b), though the definitions of normal modes and determination of their frequencies were generally good. Students commonly confused sine and cosine, or felt it necessary to write out their GCSE mnemonics; a surprising number thought $\sin\vartheta \approx \vartheta/l$, and other statements were also dimensionally incorrect. The lack of a systematic explanation of their working cost many students marks when things went awry, and attempts to work back from a given result, despite fudging with various degrees of audacity, gained few marks.

B3 Cometary orbit **44 attempts** **mean 5.8**

Many clearly thought this question to be about the application of Kepler's laws, rather than their derivation. Almost all the marks lost were through inability with basic mathematics or failure to read the question. Few could successfully differentiate $(\mathrm{d}r/\mathrm{d}t)^2$ or handle $[u\ \mathrm{d}/\mathrm{d}\vartheta)^2$, where u was a function of ϑ. Many seemed unsure of the resolution of a velocity into radial and azimuthal (tangential) components, and did not help themselves by using v to denote different things in different parts of their solutions.

B4 Gyroscopic precession **108 attempts** **score 12.4**

This was a popular question, perhaps because students had met many parts individually during the course. There were many good answers, and marks were lost in a patchy fashion for tatty diagrams, incomplete derivations, and surprisingly many numerical errors – not limited to omitted factors of 2π. There was confusion over vectors, especially the handling of vector products, and some trouble muddling vertical and horizontal. Explanations of precession were generally poor, and some circular definitions scored few marks.