Phys2006 Classical Mechanics May 2016

Many scripts suggested incomplete revision of core topics – especially rotational and planetary motion and gravity – and inadequate synthesis of material into understanding. Students were commonly unable to unpack information given in a question so as to allow its analysis, and diagrams requested to aid this process were rarely drawn with the necessary thought or clarity. In place of formal mathematical working, many offered scrappy impressionist collages that contained roughly relevant components with little logical linking.

Students generally seemed short of ideas rather than time: few solutions were truncated, some students had time to try three or four B-section questions, despite the rubric instructions, and a number were recorded to have left the exam early.

Questions B2 and B4 were very closely based upon past exam questions (2011/B4 and 2014/B3). Questions A4 and A5 followed coursework exercises, and few parts were not covered directly by lectures or exercises.

Section A **mean 9.3/20**

There was an overall lack of physical understanding when applied to the mathematical context of questions. It was worrying how few people understood what an integral physically means and how few people read the questions and absorbed the information given to them. A lot of marks were lost for simply not reading questions properly.

A1 Definitions **mean 2.3/4**

Students often got both marks available for correctly writing down the expressions for the centre of mass and the moment of inertia, although a small minority missed a factor of M or R. Most students struggled with the explanations of what they were however, often re-stating their equations, labelling what each part of the equation referred to or, as was more often the case, vaguely discussing the average mass (for the centre of mass) or the angular analogue to mass (for the moment of inertia).

A2 Moment of inertia **mean 2.0/4**

Students answered this question in many different ways. Those who drew a diagram and approached it head on by solving for the moment of inertia by integrating radially outwards from the inner ring usually got most of the marks. However, many students got integrands wrong, assumed the question was in 3 dimensions or didn't know how to solve the problem of getting rid of the radii to the fourth power at the end of the question. A very common issue appeared when students stated that inertia was additive, but then integrated from 0 to each point and then summed these answers, leading to erroneous solutions and subsequent mathematical mistakes when things didn't cancel.

A3 Cricket bat **mean 1.0/4**

There were very few good answers to this question and large fraction of the cohort did not attempt an answer to it. Those that did usually did reasonably well, although there were several different methods tried by students. The second part of the question was rarely attempted; when it was, some discussion about the parallel axis theorem was usually given although rarely in a cohesive argument.

A4 Earth gravity **mean 0.7/4**

This question was very poorly answered on the whole. Many students did not attempt the question. Those that did attempt the question stated what the local value of g would be, but then couldn't go any further. Often, students did not read the question and, instead of proving the result shown, used it and substituted in equations that they knew and hence went around in a circular argument. Some students tried to integrate g when they should have been differentiating g with respect to r.

A5 Rocket acceleration **mean 3.3/4**

Students found this question much easier than the other A section questions. Almost all correctly derived the first part of the question and most got to the final answer in the second part. Marks tended to only be lost for not writing down assumptions, but even so this was usually only half a mark. Some people lost further marks for lack of explanation as to what they were doing or why they did certain things.

Section B **mean 19.7/40**

B1 Coriolis acceleration **45 attempts** **mean 9.7**

This question yielded some patchy answers to all parts. Many could not derive the initial expression, and most proved only its scalar properties. Derivation of the Coriolis and centrifugal terms – a little subtle, but standard – often went astray and, while most could identify them, 'significance' was often limited to taxonomy. Most derivations of the geostrophic wind equation fudged the per-unit-area/volume of pressure and density, and plenty could not insert values into the given expression without error.

B2 Normal modes **53 attempts** **mean 13.2**

Some ropey explanations of normal modes lost marks for poor phrasing. Derivation of the matrix equation was mainly good, though some solutions were rather laborious, and a number foundered upon encountering a quadratic. Some assumed asymmetric mode motions of the unequal masses to have equal amplitudes, though this would have meant motion of the centre of mass. The final part was commonly omitted, though many who attempted it reached the right answer.

B3 Precession **67 attempts** **mean 7.9**

Many students seemed to have omitted precession from their revision. Precession itself was poorly explained, many did not know how torque and angular momentum are related, and angular momentum conservation was not universally mentioned. Few could derive the precession frequency, and many had difficulty parsing the rest of the question; few attempted a clarifying diagram of the device that had been described, analysed and demonstrated in lectures. Some would have remained better on track had they stuck to vector notation rather than considering scalar terms.

B4 Planetary orbits **101 attempts** **score 9.4**

This question was often dreadfully answered: but for the conservation of angular rather than linear momentum, it was pretty much an A-level question, about a straightforward and easily imaginable situation, and very similar to examples met in lectures, lecture notes and exercises. Many adopted confusing notations that muddled the velocities before and after the impulse and at the perigee; far too many thought gravitational potential energy inversely proportional to the square of the distance, and/or positive in sign; several thought angular momentum to be conserved while the rocket motor was operating; and many took the speeds before and after the rocket impulse to differ, despite the statement in the question that they were equal. Many omitted parts of the introductory section and diagram, which should have served to clarify the situation. Diagrams commonly showed the satellite after the impulse to be at its apogee, despite the radial velocity component; and a few thought the velocity to be zero at the apogee, despite the elliptical motion. Some thought the Earth to be at the centre of the ellipse rather than its focus, though this didn't generally affect the solution.