Examination Feedback for ACS342 – Feedback Systems Design
Autumn Semester 2012-13

Feedback for ACS342 Session: 2012-2013

Feedback: Please write simple statements about how well students addressed the exam paper in general and each individual question in particular including common problems/mistakes and areas of concern in the boxes provided below. Increase row height if necessary.

General Comments:

Candidates' performance in this examination ranged from outstanding to appalling, but in general, the overall performance level was disappointing.

Candidates fared well on those questions that required the application of simple learnt procedures or analysis (transfer function derivation of an *RLC* circuit, the Routh array, calculation of damping ratio, natural frequency and overshoot) but poorly, in general, on any questions that either probed their understanding of the underlying concepts or approached the design and analysis of a controller or system in a slightly different way. This is demonstrated by the fact that, faced with a design/analysis problem, many students would follow a related and set procedure covered in the lectures, even if that was not what was being asked for. Similarly, when challenged by something unusual, such as the shape of the root locus plot in Q1, candidates tended to ignore what their calculations told them and produce something more familiar. Probably these are the results of candidates attempting to just learn the key formulae and methods from the lectures, and putting no effort into developing an understanding of the subject.

A cause of great concern is the failure of many to master the mathematical basics taught in earlier years – Laplace transforms, partial fractions – or complete questions that were bookwork in nature but required some mathematical analysis and not just the simple following of a learnt procedure: root locus, Bode plots, gain margin calculation, step response of a first order system via inverse Laplace transforms, conversion of a plant to discrete time via *z* transforms.

Question 1:

The majority of candidates attempted this equation. For part (a), most candidates noticed the presence of an open-loop pole in the RHS of the *s*-plane, and equated this with instability. However, only a few candidates explained *why* a RHS pole implies instability. A significant minority of candidates performed Routh array analysis on the system, hence *showing* that the system is unstable, even though they were told this in the question; no explanation as to *why* the system is unstable was given.

Parts (b) and (c) were straightforward bookwork and were done well, in general. In (b), some candidates, having determined that $K > 0$ and $K_M * K > 1$, seemed to think that this implies $K_M > 1$.

Candidates clearly struggled with part (d), drawing the root locus, and only one candidate in the whole cohort produced the correct plot. The question was one of following textbook rules and combining the results for a single plot. Many candidates failed to correctly calculate asymptotes and breakpoints, or missed out steps in the construction of the plots. The presence of two breakpoints – one for exit and one for entry – confused most candidates, and many of those who did managed to calculate both arbitrarily discarded one of them. Perhaps more worryingly, a number of candidates calculated the salient points correctly, but then ignored what the calculations were telling them and drew something else. A few attempted first to derive the closed-loop transfer function, determine its poles, and apply the root locus plotting rules to that, indicating a lack of understanding of what the root locus actually is. Some candidates drew unstable root loci, even though they had just shown in part (b) that the system is stable under certain conditions, indicating a lack of understanding of what the root locus is telling us about the stability of the system. The general quality of sketches was very poor: unlabeled axes, unclear and untidy loci.

Part (e) produced was attempted with mixed success. While several candidates did notice what the new controller would to the system, and made the correct conclusion, many made just the opposite conclusion and attempted to justify it with hand-waving (and incorrect) arguments.

Question 2:

The majority of candidates attempted this question, yet most struggled. Part (a) was standard bookwork, and contained no sting in the tail. Despite this, a significant number of candidates did not manage to produce the correct plots. Among those who did, very few obtained full marks since the quality of sketches was – generally – poor; minimal or no annotation, scruffy lines, unclear markings.

Part (b) was a textbook gain margin calculation, which surprisingly few candidates got right. A common mistake was to equate the 10 dB gain margin given in the question as the *gain* of the system at the phase crossover frequency, when it should be that – in order to achieve a gain margin of 10 dB – the gain of the system at this frequency is *minus* 10 dB.

Part (c) upset most candidates, perhaps because even though what was being asked was actually very simple, it was outside of the comfort zone of the learned routine for compensator design, and required some understanding. Many attempted to regurgitate the design process for a phase-lead compensator, which failed since this was not what was being asked. A minority did correctly observe that all what was being asked was to determine what value of alpha would mean that the gain of just the compensator, $C(s)$, is minus 3 dB at the provided frequency. Those that did notice this were rewarded with very simple calculations. Those that did not, attempted to determine, inter alia, the gain and phase of the system $G(s)$ (rather than the compensator), which was far more complicated and unnecessary.

Question 3:

The majority of candidates attempted this question. Part (a) – straightforward circuit analysis – was done very well in general. Furthermore, most, though fewer, candidates correctly answered part (b). Some candidates laboured over their answers, while others produced the correct transfer function and steady-state error in a minimal number of steps by noticing the potential divider and that the capacitor and inductor contribute nothing to the steady-state response. A couple of common mistakes were evident in the attempts of those who did not obtain the correct answers. Some recalled the formula from the lectures for the steady-state error of a *closed-loop* system, even though this circuit system was open loop. Some inserted the given component values into the transfer function but could not then see what to do to obtain the steady-state output value.

Almost all candidates failed to solve part (c), and the majority did not even try. Most of those who did attempt this part offered questionable arguments that led to the correct answer, which was given in the question, being shown, although at least these revealed at an understanding of what was being asked. A tiny minority noticed that all that was involved was finding the maximum value of the provided function, by differentiating it and setting the result to zero: a basic and fundamental mathematical technique. Only one of those managed to differentiate the function correctly and obtain the correct result.

Part (d) was attempted by most, and most candidates made good progress and obtained a final answer by using a correct approach. Many of those final answers were numerically incorrect, since a very common mistake was to *directly* equate the provided transfer function with the standard second-order function, without noticing that the denominator of the provided function needed to be divided by LC to be in the correct form.

Question 4:

A minority of candidates attempted this question, perhaps because of the longer textual description and the presence of digital control and *z* transforms in the final part. Most struggled, even though the proportional of bookwork and standard techniques was higher than usual in this question.

The first two parts were on steady-state error analysis. Most candidates fared well with part (a), though some mistakenly determined the velocity or ramp error constant, which was not being asked for; perhaps the confusion arose because the inputs and outputs to this system were angular speeds. Part (b), behind the description, was a textbook example of determining the step response of a first order system, via the inverse Laplace transform of the forced closed-loop transfer function (CLTF), then differentiating it to obtain the initial rate of response. Most candidates failed to do this. Alarming mistakes include, having obtained $Y(s)$ = CLTF * $R(s)$, then writing $y(t) = L^{-1}$\{CLTF\} * $r(t)$, revealing a fundamental misunderstanding of Laplace transforms. Some missed the fact that partial fractions of CLTF * $R(s)$ had to be taken before applying the inverse transforms. Very few spotted that they needed to differentiate the derived time response to obtain an angular acceleration.

Part (c), and the later part of (b), asked for explanations as to why proportional control was not suitable for this system and how adding integral control would improve the time response. Mostly, candidates reproduced the advantages and disadvantages of P versus I, as had been covered in the lectures, without thinking about what was being asked.

Part (d) was done poorly, yet was a bookwork conversion of a continuous-time plant to the discrete-time domain. A common mistake was, having determined that $C(z)G(z)$ is obtained from the z-transform $Z\{\text{zoh}*G(s)*C(s)\}$, decomposing the latter to $Z\{\text{zoh}\}*Z\{G(s)\}*Z\{C(s)\}$ (c.f. the mistake with Laplace transforms in part (b)). Another mistake was to determine $C(z)$ and $G(z)$ separately as $Z\{\text{zoh}*G(s)\}$ and $Z\{\text{zoh}*C(s)\}$. As in part (b), candidates missed the fact that partial fractions were required as an intermediate step, or if they did notice this, struggled with taking partial fractions in the case of a repeated root. One candidate managed to obtain the required transfer function using the correct procedure.