GCE

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Mathematics

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Examiners' Report

Edexcel GCE

Mathematics

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Specification 6663

Introduction

This paper was accessible and nearly all the students were able to make some progress on most questions. The first 5 questions were generally tackled very well but 6(c), 7(b), 8(c), 9(e) and 10(c) proved more discriminating. In C1 candidates would make life a lot easier for themselves if they learnt how to factorise a 3 term quadratic. There were several occasions on this paper (notably question 5 and 9(d)) where students resorted to using the formula and made life very difficult for themselves. The students should be equipped with the full range of techniques for solving quadratic equations and not always rely on being able to use the formula. Lots of marks were lost for poor arithmetic.

The proof in question 9(a) is a standard one and expressly mentioned in the specification. Students should be aware of the need to provide a precise and accurate demonstration, some of the attempts offered this time lacked rigour or were poorly presented.

Some centres seem to be routinely issuing rough paper to students for this, and other examinations. Often this is then attached to the back of the script (which means the paper can not be scanned) and in most cases it is so illegible that the examiners can make little sense of it. Such a practice also discourages students from showing their working and sometimes therefore means they lose marks. There is sufficient space given in each question for most students to write their full solutions (including any rough work) and if, in the unlikely situation that they run out of space, they can of course continue on a separate sheet which should be attached in the usual way.

Report on individual questions

Question 1

This was a successful starter to the paper and nearly all the candidates were able to make some progress. Part (a) was rarely incorrect although sometimes the answer was given as ± 2. The negative power led to a number of errors in part (b). Some thought that $8^{-\frac{2}{3}} = 8^{\frac{3}{2}}$ whilst others thought that a negative answer (usually – 4) was appropriate. Most knew that the negative power meant a reciprocal and the correct answer was often seen.

Question 2

This was another straightforward question for many candidates and the principles of differentiation and integration were understood by most. The negative power caused problems for some again, they realized that the term $-\dfrac{4}{x^2}$ needed to be written as $-4x^{-2}$ but did not always apply the rules successfully. In part (b) some could not simplify $-\dfrac{4x^{-1}}{-1}$ to $+4x^{-1}$ and a sizeable minority lost a mark for failing to include a constant of integration.

Question 3

This question was well attempted by most candidates. In part (a) the most successful approach involved completing the square although sign errors such as $(x+4)^2$ or $(x-4)^2-13$, from +16 – 29, were not uncommon. Some students attempted to compare coefficients but often they got no further than expanding the brackets as they did not fully appreciate the concept behind this technique.

In part (b) those who used their correct answer from part (a) were usually able to complete the question quickly and accurately. A large number though chose the more difficult route using the quadratic formula. Most produced a correct solution but a large number only divided the first term of the numerator by 2 and obtained $4 \pm 6\sqrt{5}$ whilst others simplified $\frac{8 \pm \sqrt{180}}{2}$ to $4 \pm \sqrt{90}$. Occasionally dubious square rooting occurred with $(x-4)-\sqrt{45}$ =0 following directly from $(x-4)^2-45=0$.

Question 4

In part (a) over 90% of the candidates sketched a quadratic curve passing through the origin but the stretch was sometimes in the x-direction. Part (b) was generally answered more successfully than part (a) and the curve was usually moved correctly although a minority translated it to the right.

Coordinates were not always written carefully and (2, 0) or (0, -2) were often seen instead of (-2, 0) in part (b).

Question 5

Generally this question was answered well although there were a number of sign slips either in the initial substitution, using $x = 1 - 2y$, or losing the minus sign from $y = -\frac{14}{5}$ when substituting back to find x. It was encouraging to see few students using the more difficult $y = \frac{x-1}{2}$ substitution.

This was one question where an ability to factorise a quadratic expression would have helped many candidates. A large number attempted to use the formula and sometimes could not simplify $\sqrt{576}$, another error that was seen using this approach was to call the solutions to their equation in y, $x = \ldots$ and this meant they lost the final two marks. There were only a few attempts that used "false squaring" namely $x^2 + 4y^2 = 1$ and the vast majority realized that simply "spotting" the solution (5, 2) did not constitute a full solution and therefore gained few marks.

Question 6

Part (a) was usually correct but there were some sign errors and a common mistake was to follow $8x>2$ with $x > 4$. In part (b) the critical values were usually found without difficulty although even here some used the formula. Those who drew a sketch often went on to establish the correct regions easily but sometimes they expressed them in an inappropriate form such as $0.5>x>3$. Others made the usual errors of choosing the inside region, $0.5 < x < 3$ or simply giving the answer as $x > 0.5$, $x > 3$.

Part (c) proved to be a good discriminator and whilst a good number of students were able to combine their answers from parts (a) and (b) successfully, a large number gave incomplete or incorrect solutions or tried to start from scratch and got lost in a mix of algebra and inequalities. The use of a simple number line would have helped some but others thought $0.25 > 0.5$ and so missed the finite region.

Question 7

Most candidates could square the bracket though sometimes the examiners saw a $-x$ or an $x^{\frac{1}{4}}$. The division by $\sqrt{x}$ was usually carried out correctly but occasionally the first term was given as $9x^{\frac{1}{2}}$ instead of $9x^{-\frac{1}{2}}$.

In part (b) the fractional powers created few problems for the integration, but division by fractions caused errors to appear for a number of candidates with $\frac{9}{\frac{1}{2}}$ often being simplified to 4.5. Most candidates knew that they had to include a "$+c$" and then use the given values of x and y to find its value. About 30% of the candidates failed to include the constant and automatically denied themselves access to the last 3 marks. The fact that a number of these students still tried to substitute the given values in their expression shows that there is some misunderstanding surrounding this topic.

Question 8

Most candidates found a correct equation for l_1 but the final mark was often lost as they did not leave it in the required form. There was some suggestion that the term "integers" was not universally understood. In part (b) the majority were able to give the equation of l_2 in the form $y = -2x$ and the solution of the two linear equations to find the point P was tackled well. The answers to part (c) though were disappointing. The coordinates of C were usually given correctly but far too many candidates failed to draw a diagram, and many lost time and marks by assuming that the triangle was right angled at P and then proceeded to find the lengths of OP and CP.

Question 9

Whilst it was clear that many centres had encouraged their students to learn an appropriate proof for part (a) there were a surprising number of students who were not well prepared for this part of the question and the success rate was under 50%. Errors included a lack of + signs and use of $a + nd$. Some candidates attempted to add the terms in pairs, but gave no consideration to series with an odd number of terms. In part (b) the answer was usually correct although sum tried to use $d = 2$ and others used the formula for the sum of 21 terms. Part (c) was generally answered quite well too although there was some inappropriate altering of signs to achieve the printed result. Those who factorized in part (d) had no problems here but a disappointing number attempted to use the formula and were defeated by the arithmetic. In part (e) a common incorrect answer was that 100 months (or years) was too long rather than stating that the loan would have been repaid by then or that the 100^{th} term was negative.

Question 10

A number of candidates did not answer this question which could have been due to a lack of time or a reflection of the difficulty of this question. Part (a) was usually answered correctly but some evaluated $\frac{1}{3}3^3$ to get 3. Most differentiated in part (b) to find the gradient although a minority tried simply substituting values into $y = mx + c$. A number of candidates were unable to calculate the gradient correctly at $x = 3$ ($9 - 24 + 8$ was often incorrectly evaluated). Many had no idea how to tackle part (c) but those that did scored well although a surprising number followed a correct substitution of $x = 5$ with $y = 41\frac{2}{3} - 57$ but then gave the final answer as $y = 15\frac{1}{3}$ instead of $y = -15\frac{1}{3}$.

Core Mathematics Unit C2

Specification 6664

Introduction

For average candidates, this paper proved to be a fair test of the specification, with enough familiar questions to give them the opportunity to demonstrate their knowledge and understanding. Weaker candidates often had particular difficulty with trigonometry, logarithms and the coordinate geometry of the circle, but were usually able to make some progress in the relevant questions on these topics. Standards of algebra, particularly in questions 4, 8 and 10, were often disappointing. Just a few parts of questions proved more generally demanding.
Most candidates appear to have had time to attempt all ten questions, but there was occasional evidence of completely blank solutions to some of the longer questions. A number of questions required candidates to round their answers to a particular degree of accuracy, and it was disappointing that marks were often lost by failure to round correctly or as demanded. Most candidates showed their methods clearly and found the solution spaces provided on the paper to be adequate.

Report on individual questions

Question 1

There were many completely correct answers to this question. Most candidates used the expected method of equating $\frac{\mathrm{d}y}{\mathrm{d}x}$ to zero, but occasional solutions based on the symmetry of the quadratic curve were seen. Weaker candidates sometimes found the points of intersection of the curve with the x-axis but could not proceed any further.

Question 2

Most candidates were able to solve $5^x = 8$ correctly in part (a), although the answer was sometimes not rounded to 3 significant figures as required. The usual method was to use $x = \frac{\log 8}{\log 5}$, but trial and improvement approaches were sometimes seen.

Part (b) was a more demanding test of understanding of the theory of logarithms. Those who began by using $\log(x+1) - \log x = \log\frac{x+1}{x}$ were often successful, but common mistakes such as $\log(x+1) - \log x = \frac{\log(x+1)}{\log x}$ and $\log(x+1) = \log x + \log 1$ usually prevented the candidate from scoring any marks. Confused working, including 'cancelling' of logs, was often seen here, and there were many attempts involving an unnecessary change of base.

Question 3

Candidates who used long division rather than the factor theorem lost the marks in part (a) of this question, and those who obtained f(–4) = 0 but failed to give a conclusion lost the second mark.

There were many good solutions to the factorisation in part (b). Candidates usually found the quadratic factor by long division (which was generally well understood) or by ‘inspection’ and went on to factorise this quadratic, obtaining the correct linear factors. Occasionally the factor theorem was used to establish one or both of the remaining linear factors. Having found linear factors, it was tempting for some candidates to solve a non-existent equation, but examiners ignored such ‘subsequent working’. Those candidates whose first step was $x(2x^2 + x - 25) + 12$ made no progress.

Question 4

Most candidates had a good idea of how to use a binomial expansion, but some had difficulty with simplification, perhaps leaving their terms in forms such as $\binom{12}{1}1^{11}(px)$ and not knowing how to proceed. The most common mistake in part (a) was the failure to square p in the coefficient of the x^2 term. Those who made this mistake were still able to score method marks in part (b), but then made no further progress because their equations for p and q yielded only zero roots.

Many candidates had difficulty with part (b). Often there was confusion between ‘coefficient’ and ‘term’, and statements such as $12px = -q$ and $66p^2x^2 = 11q$ led to attempts to solve two equations in three unknowns. Rather than comparing terms, some candidates tried to write down a single expansion with terms involving both p and q, and others used $-q$ and $11q$ as values of x in their expansion.

Question 5

Well-prepared candidates often scored full marks on this question. In part (a), most recognised $\frac{\sqrt{3}}{2}$ as $\sin 60°$ (or were able to find $60°$ otherwise) and went on to subtract $10°$ to find one correct solution. The second solution ($110°$) was often missing or incorrect, a common mistake here being to subtract $50°$ from $180°$. Just a few candidates started with $\sin(x + 10) = \sin x + \sin 10$, making little progress.

Performance in part (b) was similar, in that again the second solution was often missing or incorrect. Most candidates rounded their answers to 1 decimal place as required. Only a few were tempted to proceed from $\cos 2x = -0.9$ to $\cos x = -0.45$.

In both parts, it was rare to see extra solutions either within or outside the given range.

Question 6

Completing the y values in the table was no problem for the vast majority of candidates, but it was disappointing to see many mistakes in the application of the trapezium rule in part (b). The most common problem was the misunderstanding of h, often shown as $\frac{20}{6}$ or just 20 rather than $\frac{20}{5}$. Some candidates, clearly unfamiliar with the trapezium rule formula, opted instead to calculate areas of separate trapezia, but were still usually able to proceed to a correct answer.

Part (c) proved difficult. Even able candidates were unsure of the link between the rate of flow, the area of cross-section and the volume of water, and there was a bewildering assortment of methods involving either multiplication or division by $2\,(\mathrm{ms}^{-1})$ and/or 60 (seconds). The width of the river (20 m) also featured in many attempts. A significant number of candidates failed to round their answer to 3 significant figures.

Question 7

Most candidates were confident in using the sine rule in part (a), although their diagrams were sometimes labelled with angles in the wrong place. Where the given angle was included between their two given sides, the cosine rule was occasionally used, followed by the sine rule, but a method mark and a follow-through accuracy mark were awarded where possible. Although the value of $\sin x$ was required, many candidates by-passed this demand, losing a mark, and gave only the value of x. Occasionally more fundamental mistakes were seen, including the use of just 0.5 instead of sin 0.5 and the assumption that the given triangle was right-angled.

It became clear in part (b) that many candidates were not competent, or perhaps not comfortable, in the use of radians. Answers were frequently given in degrees, but were sometimes correctly converted into radians at the end. The second possible value of x was frequently omitted. The method mark for the attempt at the second value was, however, awarded for appropriate work in either radians or degrees.
A mark was often lost by failure to round answers to the required degree of accuracy

Question 8

Although some candidates produced very good solutions to parts (a) and (b), others were clearly confused or produced poor algebra. Many were unable to perform the necessary manipulation to find the centre and radius of the circle, and seemed unwilling to accept that the centre could lie on the x-axis, sometimes interpreting the '9' in the equation as '$9y$'. The technique of 'completing the square' was often badly handled.

Fortunately, parts (c) and (d) were accessible despite failure in (a) and (b). The usual method in part (c) was to substitute $y = 0$ into the equation of the circle, then to solve the resulting quadratic equation. Many candidates completed this correctly, although $x = 0$ instead of $y = 0$ was sometimes seen.
Success in part (d) was rather variable, but it was clear that a diagram helped to clarify the demand here. Those who realised that the required line was perpendicular to the tangent often proceeded to produce a correct equation, while others simply used the given gradient $\frac{7}{2}$ in their straight line equation. A few attempts involving differentiation were seen, but these were almost invariably unsuccessful.

Question 9

Those who were familiar with the required proof of the sum formula for the geometric series were able to produce good solutions to part (a), but all too many failed to demonstrate complete understanding of what they were trying to show, losing one or two marks. Many candidates were unable to produce anything worthy of marks here.
Whether working with the term formula for a geometric series or otherwise, most candidates managed to score at least the method mark in part (b). Common mistakes included finding the third term (instead of the fourth) and failing to round to the nearest £100.
In part (c), those who were unable to find the correct common ratio (using perhaps 0.04 or 1.4, or even 4) were limited to just one mark. An extremely popular mistake was to use $n = 19$ (found by subtracting the years 2024 and 2005) rather than 20. Just a few candidates laboriously calculated the total salary by finding and adding the salaries for all 20 years.

Question 10

There were many very good solutions to part (a), scoring full marks or perhaps losing just one or two marks for slips in accuracy. It was disappointing, however, that so many candidates used an unnecessarily long method, finding the equation of the straight line through P and Q, then integrating, when it was much simpler to use the formula for the area of a trapezium (or equivalent). Integration techniques were usually sound, although $8x^{-2}$ was occasionally integrated to give $\frac{8x^{-3}}{-3}$. Sometimes candidates simply found the area under the curve and did not proceed any further.

Part (b) required candidates to use calculus to show that y was increasing for $x > 2$, and responses here often suggested a lack of understanding of the concept of an increasing function. Weaker candidates often made no attempt at this part, or simply calculated values of y for specific values of x. Usually, however, $\frac{dy}{dx}$ was found and there was some indication that a positive gradient implied an increasing function, but again a common approach was to find values of the gradient for specific values of x. Accurate and confident use of inequalities was rarely seen. Although there were some good solutions based on proving that $x = 2$ was a minimum, completely convincing and conclusive arguments in part (b) were rare.

Core Mathematics Unit C3

Specification 6665

Introduction

Candidates generally showed good knowledge of all parts of the syllabus. Questions 1 to 4 were usually found to be straightforward while questions 5(d) and 6 (b) and (d) provided most discrimination There were very few non–attempts at questions seen, indicating that the paper was accessible and that there was adequate time to finish it. Algebraic manipulation was good on the whole although brackets or lack of them still caused problems. The precision and detail required to show the printed answers was lacking in some scripts.

Report on individual questions

Question 1

a) A variety of methods were used and most candidates were able to prove the identity. Many divided the given statement $\cos^2\theta + \sin^2\theta = 1$ by $\cos^2\theta$. Others started with the answer, replacing tan with sin/cos and sec with 1/cos. (Where an answer is printed it is important that each step of the argument is clearly shown to gain full credit.)

b) Most candidates solved the trigonometric equation confidently, but many used sines and cosines rather than take the lead from the question and using sec. Factorisation was good and the solution $\theta = 0$ was usually found (but also 360, which was outside the range). For those who used the correct equation, the other two angles were found correctly. A number of candidates changed sec into $\sec^2$ at the start of this question, changing the question quite radically. There were not many who needed the final follow through mark, since most who reached that stage had the correct value for θ.

Question 2

a)(i) Most candidates demonstrated good knowledge of trigonometric differentiation but there were a number of errors particularly in the derivative of sec 2x.
a(ii) Candidates did not always apply the function of a function rule, but the most common error seen in this part was d/dx(ln2x) = 1/2x or 2/x. Expanding using the binomial theorem prior to differentiation was rarely seen and when used, often contained inaccuracies.

b) Knowledge of product and quotient rules was good but execution sometimes poor. There was a lack of sustained accuracy in algebra manipulation and much alteration to obtain the answer on the paper. Most candidates did not factorise out the (x-1) factor until the last line of the solution. There were however a few excellent solutions using the division method. Many replaced solutions to this part were inserted later in the answer book, and candidates are advised to make clear reference to such replaced solutions (with a page reference) in their original solution.

Question 3

a) Candidates found this the easiest question to complete accurately. Some did not use the lowest common denominator but mostfactorised later. There was a certain amount of alteration of signs in order to obtain the given answer.

b) The inverse function was generally found correctly, although some candidates confused $f^{-1}(x)$ with $f^{/}$ (x).

c) fg(x) was worked in the correct order by the majority of candidates. A significant group omitted the second solution x = -2 in their answer, focussing incorrectly on the domain given in part a). Another error was to find fg(1/4) instead of solving fg(x) = ¼.

Question 4

a) Most candidates were confident differentiating both e ^{x} and ln x. Some candidates misread f(x) and had ln(x – 2) instead of lnx -2. A number did not simplify their fraction to 1/(2x) but they were not penalised for this.

b) They usually completed the rearrangement in part b) successfully although often needing several stages before reaching the answer on the paper. Some failed to replace the x with an alpha and a number had problems with their algebraic fractions.

c) Candidates are very competent at obtaining values using an iteration formulae but some are not precise about the required number of decimal places.

d) There was general familiarity with the change of sign method for determining a root but not always sufficient decimal places, and some intervals were too wide. Conclusions were sometimes missing. Some answers used f instead of f', and others used an iterative approach despite the instruction in the question.

Question 5

This question yielded the most variety of solutions: some showed good quality mathematics with concise methods and accurate answers.
a) This was generally accessible to the candidates, but some could not move past the given identity.

b) There were many correct answers to this part, but candidates did not always show sufficient working which is crucial when answers are given on the paper. There were some sign errors in the processing steps. Most candidates worked from left to right.

c) The method here was generally well known but inaccuracies occurred and e.g. Rsinα = 6 was too often seen. Some candidates failed to give their answers in this part correct to at least 3sf.

d) Many candidates failed to notice the connection between b) and d). Not all candidates were able to solve the trig equation successfully, with sinθ sometimes being lost rather than giving the solution θ = 0. Those that did go on to solve the remaining equation were frequently unable to proceed beyond inverse sin to the correct answer 2.12. Some candidates attempted a squaring approach but generally ended up with excess solutions. Candidates did not always work in radians to 3 sf.

Question 6

a) and b) f(x+1) was usually correct, with the graph translated one unit to the left, but f(|x|) was more difficult for many candidates. The most common errors were use of |f(x)| and only plotted for x » 0. Candidates were generally well trained in labelling coordinates but the ‘b’ was sometimes missing in b).

c) Candidates found this part straight forward.

d) A squaring approach was used by some candidates but most solved linear equations. A number obtained two solutions x = -3/4 and x = -1/6 but then failed to eliminate x = -3/4. Candidates who drew y = 5x on their sketch usually isolated x = -1/6 as the single solution.

Question 7

a) The value of a was calculated accurately by most candidates, but a significant group did not substitute t = 0. Also a number of answers were produced where a = 0.12 was substituted to give p=300, and this was not given full credit.

b) Candidates could not always cope with the algebra manipulation and some found difficulty using logs correctly; e.g. writing $1850 = 114\, e^{0.2t}$ then $\ln 1850 = \ln 114\, \ln e^{0.2t}$.

c) Candidates frequently did not show convincing work here, with the answer following from the question with no working in between. It was necessary to show the division of numerator and denominator by e^0.2t to justify getting the given result.

d) Candidates rarely used the concept of limiting values. Many candidates simply substituted P = 2800 in the formula given in c) and showed that $e^{-0.2t} = 0$, which was insufficient without further statements. There were number of inequality errors seen There were however some excellent solutions which clearly indicated that $e^{-0.2t} > 0$ implied that the denominator was >0.12 and that the fraction was < 2800. Some illustrated their solution with a graph of an increasing function tending to an asymptote.

Core Mathematics Unit C4

Specification 6666

Introduction

This was the first paper set on this specification. It is not easy to compare it with previous papers but the general impression was that it was found somewhat more demanding than recent P3 papers. However there were questions suitable to a wide range of ability. There were questions or parts of questions that could be tackled successfully by almost all candidates and there were some much more testing questions, particularly towards the end of the paper. Questions 7(d) and 8 were found particularly difficult and, although many did not complete the paper, this seemed to the result of the difficulty of these questions rather than a lack of time and the majority of candidates probably completed the work that they were able to do successfully. Most candidates used calculators appropriately and provided sufficient working for the examiners to judge the methods which had been used.

Report on individual questions

Question 1

In general, this was well done but a substantial minority of candidates were unable to carry out the first step of writing $(4-9x)^{\frac{1}{2}}$ as $2\left(1-\frac{9x}{4}\right)^{\frac{1}{2}}$. Those who could do this could usually complete the question but many errors of sign manipulation were seen.

Question 2

Almost all candidates could start this question and the majority could differentiate implicitly correctly. This is an area of work which has definitely improved in recent years. Many, having found $\frac{dy}{dx}$, could not use it and it was disturbing to find a substantial number of students in this relatively advanced A2 module proceeding from $\frac{x+y}{3y-x}=0$ to $x+y=3y-x$. Those who did obtain $y=-x$ often went no further but those who did could usually obtain both correct points, although extra incorrect points were often seen.

Question 3

Almost all candidates knew how to do this question and it was rare to see an incorrect solution to part (a) and nearly all could make a substantial attempt at part (b). However the error $\int \frac{3}{2x-3}\,dx = 3\ln(2x-3)$ was common. The standard of logarithmic work seen in simplifying the final answer was good and this, and the manipulation of exponentials elsewhere in the paper, is another area in which the standard of work has improved in recent examinations.

Question 4

This was a question which candidates tended to either get completely correct or score very few marks. If the $\mathrm{d}x$ is ignored when substituting, an integral is obtained which is extremely difficult to integrate at this level and little progress can be made. Those who knew how to deal with the $\mathrm{d}x$ often completed correctly. A few, on obtaining $\tan\theta$, substituted 0 and $\frac{1}{2}$ instead of 0 and $\frac{\pi}{6}$. Very few attempted to return to the original variable and those who did were rarely successful.

Question 5

Those who recognised that integration by parts was needed in part (a), and these were the great majority, usually made excellent attempts at this part and, in most cases, the indefinite integral was carried out correctly. Many had difficulty with the evaluating the definite integral. There were many errors of sign and the error $\mathrm{e}^0 = 0$ was common. The trapezium rule was well known, although the error of thinking that 6 ordinates gave rise to 6 strips, rather than 5, was often seen and some candidates lost the final mark by not giving the answer to the specified accuracy.

Question 6

This proved a testing question and few could find both $\frac{\mathrm{d}x}{\mathrm{d}t}$ and $\frac{\mathrm{d}y}{\mathrm{d}t}$ correctly. A common error was to integrate *x*, giving $\frac{\mathrm{d}x}{\mathrm{d}t} = 2\ln(\sin t)$. Most knew, however, how to obtain $\frac{\mathrm{d}y}{\mathrm{d}x}$ from $\frac{\mathrm{d}x}{\mathrm{d}t}$ and $\frac{\mathrm{d}y}{\mathrm{d}t}$ and were able to pick up marks here and in part (b). In part (b), the method for finding the equation of the tangent was well understood. Part (c) proved very demanding and only a minority of candidates were able to use one of the trigonometric forms of Pythagoras to eliminate *t* and manipulate the resulting equation to obtain an answer in the required form. Few even attempted the domain and the fully correct answer, $x \;|0$, was very rarely seen

Question 7

This vector question proved an excellent source of marks for candidates and fully correct solutions to both parts (a) and (b) were common, although many spent time fruitlessly trying to solve simultaneous equations before realising that the **k** component gave λ directly. Part (c) was also generally well done but there were candidates who clearly expected $\overrightarrow{AB}$ and $\overrightarrow{BC}$ to be equal, or at least parallel, and gave up when they were not. Part (d) proved difficult even for the strongest candidates. Given a well-drawn diagram, the answer can be written down (the examiners do not insist upon working in such cases) and the idea is one that has appeared on GCSE papers but it remains inaccessible to many candidates and it was not unusual to see 2 or more pages of complex algebra, involving distance formulae which the candidate was unable to solve.

Question 8

This proved by far the most difficult question on the paper. When an explanation is asked for an equation, the candidate must make specific reference to the elements of that equation in their explanation. For example, $\frac{\mathrm{d}V}{\mathrm{d}t}$, needed to be explicitly identified with the rate of change (or increase) of volume with respect to time. The loss of liquid due to leakage at a rate proportional to the volume needed to be identified with the term $-kV$. Few could make any progress at all with part (b). The question was at a level of abstraction unexpected by most candidates and there was much confusion between the various constants, k, A and B, occurring in the question. After an attempt at part (a), it was not uncommon for candidates to simply give up. The majority were unable to separate the variables. When separation and integration were achieved the constant of integration, if it was recognised at all, tended to be confused with k or subsumed into A or B. Those who got an answer in the correct form in part (b), even if it was incorrect, could usually demonstrate a correct method in part (c) and obtain some credit.

Pure Mathematics Unit P1

Specification 6671

Introduction

The paper seemed to be accessible to the vast majority of candidates and there was no evidence of any time problems.
Question 1 was a friendly starter for most candidates and questions 3, 4, 7 and 8 were usually well attempted, but generally there were parts in all questions where most candidates were able to gain some credit.
It was noticeable that where the area of a triangle was required, in questions 3 (b) and 4 (c), candidates often penalised themselves with long methods or made wrong assumptions about the triangle. The proof in question 6 was very much hit or miss and it was clear that the majority of candidates had not seriously learnt it. Part (d) of the same question and part (e) of question 8 were good discriminators, and only the very best candidates gained full marks in question 5.

Report on individual questions

Question 1

The vast majority of candidates gained the method marks and many went on to score four or five marks; the four mark score was usually due to the omission of the arbitary constant in part (b).
Differentiation and integration of $-\frac{4}{x^2}$ caused problems for some candidates, and those who wrote y as $\frac{6x^3 - 4}{x^2}$ before differentiating were usually defeated.
Providing $8x^{-3}$ in part (a) and $+ 4x^{-1}$ in part (b) had been seen, subsequent errors such as writing these as $\frac{1}{8x^3}$ or $\frac{1}{4x}$ respectively, were not penalised, but it should be noted that such errors with indices were quite common.

Question 2

Good candidates produced good succinct solutions but there were many candidates who, through lack of a good strategy or poor algebra, did not score well.

In part (a) the value of a was often correct, although $a = +4$ was seen frequently. Considering that this was an easy exercise in completing the square, the coefficient of x being unity, too many solutions showed a lack of understanding of the method. Many candidates who compared coefficients also often lost marks too easily because of sign errors. The answer $b = -29$ was seen often from weaker candidates.

In answering part (b) the majority of candidates chose to use the quadratic equation formula rather than the "hence method" of using their answer to part (a). In some cases that was a very wise move, but it was a pity to see absolutely correct answers to (a) disregarded in answering part (b).

For those candidates who reached the stage $x = \dfrac{8 \pm \sqrt{180}}{2}$, or better, it was disappointing to see so much poor "cancelling", so that answers such as $x = 4 \pm \sqrt{180}$ or $4 \pm 6\sqrt{5}$ or $4 \pm \sqrt{90}$ were quite common.

Although statements like $(x - 4)^2 - 45 = 0 \Rightarrow (x - 4) - \sqrt{45} = 0$ were not seen too frequently, correct answers following such work were not treated favourably !

Question 3

This was a good question for a large number of candidates.

There were a few candidates who had no idea how to tackle part (a) but, in general, the method mark was gained by the vast majority of candidates. Candidates who found the angle in degrees first and then converted to radians did often lose the A mark, however, because of lack of exactness.

In part (b) although a few candidates used a wrong formula for the area of a sector, e.g $\frac{1}{2}\pi r^2 \theta$, finding the area of triangle DOC proved more of a problem. The most common errors seen were:

(i) giving the area of the triangle as ½ x 30 x 30 (in effect treating as right-angled) or as ½ x 30 x 30 x 1.4 (omitting "sin");
(ii) in splitting up the triangle and having a method error such as considering the altitude from D to OC as a line of symmetry;
(iii) after correctly stating "area = ½ x 30 x 30x sin 1.4", using 1.4º rather than 1.4 radians so that the answer of 10.99m^2, for the area of the triangle, was seen quite frequently.

The mark scheme was generous in the sense that the A marks for the area of the sector and the triangle only required a correct unsimplified statement (not the actual numerical answer), and so an error such as that in (iii) only lost the final mark in the question.. It was also common to see the final answer not given to the nearest m^2, as requested in the question.

Question 4

The first two parts of the question should have been accessible to candidates and, for the vast majority, that proved to be the case. In part (a) most candidates found a correct equation of line l_1 but many lost the final mark for not writing the equation with integer coefficients. Although there was a large number of candidates who scored full marks in part (b), it was still a little disappointing to see errors such as $x - 3(-2x) - 21 = 0 \Rightarrow 7x = -21$ or $5x = 21$. Some candidates formed the equation of l_2 assuming it passed through (9, –4); not surprisingly they found that l_1 and l_2 intersected in the point (9, –4) !

Part(c) proved more discriminating than expected. Many candidates did not realise how easy it was and many attempts were long, involving finding the lengths of each side of the triangle and an angle, often using the cosine rule; even if the method was correct these solutions invariably resulted in the loss of the final mark because the *exact* area was not found. It was very common, however, to see a wrong strategy, such as considering the triangle as if it were right-angled or isosceles. Another common error was to set $y = 0$ to find the coordinates of C.

Question 5

Although tan $(3x + 20°)$ = tan $3x$ + tan 20° was seen from weaker candidates, the first three marks were gained by a large number of candidates. Consideration of the third quadrant results was generally only seen from the better candidates and so two correct solutions, and more particularly three correct solutions, were not so common. Candidates who used the correct expansion of tan $(3x + 20°)$ often made subsequent errors and it was rare to see all marks gained from this approach.

In part (b) many candidates gained the first method mark, although "division errors" such as "$2\sin^2 x + \cos^2 x = \frac{10}{9} \Rightarrow 2\tan^2 x + 1 = \frac{10}{9}$" were common.
It was surprising to see the number of candidates who, having reached a correct result such as $\sin^2 x = \frac{1}{9}$, lost at least one of the final two marks, and it was only the best candidates who scored all four marks in this part. The most common, and not unexpected error, was to solve only sin x = + ⅓, but often the answer was not corrected to 1 decimal place and so this mark was lost.

Question 6

Candidates who had learnt a proof for part (a) were often able to reproduce it, but such candidates were in the minority and full marks for this part were seen infrequently.
Most candidates gained the mark in part (b), and part (c) was often a good source of marks. However, the modal mark in part (d) was one; the most common answers being100100 {just considering S(100)} and 104100 {considering an AP with first term 23 but with 200 terms}. Only the better candidates had a complete strategy, correct solutions being equally divided between finding S(100) – S(4), although S(100) – S(5) was common, and using a formula for the sum of an AP with first term 23 and 196 terms.

Question 7

This was often a very good source of marks for candidates, with many candidates scoring full marks. In part (a) the majority of candidates realised that differentiation was required and were able to complete the solution, although it was clear that some candidates were helped by the answer being given. However, solutions such as $x^{\frac{1}{2}} = 2 \Rightarrow x = \frac{2}{½} = 4$ were seen.

The mark scheme was quite generous in part (b) for finding the area under the curve, but in general the integration was performed well. This helped candidates score well here, even if they did not have a complete method to find the required area, or made mistakes in finding the area of the trapezium.

Candidates who found the equation of the line AB (some did as a matter of course but then did not use it) in order to find the area under the line, or to find the required area using a single integral, clearly made the question harder, more time consuming and open to more errors, in this case. Errors in finding the equation of the line were quite common; usually these occurred in finding the gradient or in manipulating the algebra, but it was not uncommon to see a gradient of –3 used from $\frac{\mathrm{d}y}{\mathrm{d}x}$ in part (a) with $x = 1$ substituted.

Question 8

This was another good source of marks for the majority of candidates, although part (e) was a discriminator at the top end, with only the better candidates able to correctly interpret the request.

Part (a) did require the use of the factor theorem, which was not understood by many candidates, who just showed the factorisation of f(x). Such candidates, however, had a head start in part (b), which was generally well answered. Some candidates made heavy weather of gaining the one mark in part (c), thinking that they needed to find the stationary values to identify Q, and it was quite surprising to see the number of candidates who did not gain the single mark in this part for some reason. The majority of candidates knew what was required in part (d) and any errors tended to be slips in the main, although some candidates were confused between tangent and normal and others felt they had to solve $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$. Many candidates went on to give the equation of the tangent at P unnecessarily.

Part (e) proved too taxing for the majority of candidates, who were not able to make a start, and although there were many good solutions these were clearly from the more able candidates.

Pure Mathematics Unit P2

Specification 6672

Introduction

Many candidates acquitted themselves very well on this paper. The majority appeared to be well prepared and to have a sound grasp of the syllabus. Most candidates completed the paper. It was pleasing to note that most had sufficient space within the allotted pages to complete their responses, although some candidates went on to use additional sheets having left allotted pages blank, and several candidates are not comfortable with drawing a sketch on plain paper. A lack of understanding of the functions in use led several candidates to break the laws of algebra, calculus and trigonometry without apparent concern. In many instances, the lack of algebraic confidence caused candidates to produce longer answers than necessary, and created situations that were more difficult to handle than the questions intended.

Report on individual questions

Question 1

Most candidates found this question quite accessible.

(a) A minority chose to solve this part using trial and improvement. Quite a few did not round to 3 significant figures. Candidates who started with the form $\log_5 8$ were often not able to progress beyond this.

(b) This was often started well, but there was some confusion when it came to forming an equation without logarithms. This process often took several more steps than necessary. A small, but significant proportion made no attempt at all.
Lines such as "$\log (x + 1) = (\log x)\log(1) = 0$ since $\log(1) = 0$" and "$\log(x + 1) = \log x + \log 1$" were popular options amongst the weaker candidates.

Question 2

Many candidates scored very well on this question.

(a) The coefficients of 12 and 66 were almost always correct, although 66p was a popular alternative to $66p^2$. A few candidates were confused between $\begin{pmatrix} 12 \\ n \end{pmatrix}$ and $\frac{12}{n}$. Some left out the first term, and some had correct coefficients matched with the wrong powers of x.

(b) There was some confusion between coefficients and terms, and also several candidates who tried to substitute $-q$ and $11q$ for x and x^2 respectively. When comparing coefficients some students got into problems by including x's. Many however did obtain the correct pair of simultaneous equations and were largely successful at solving them to find p and q. There were some sign errors in the solutions, particularly when squaring $\left(\frac{-q}{12}\right)$.

Question 3

This was completed successfully by a large proportion of candidates.

(a) The table was frequently completed correctly, although some candidates used a lot of paper to achieve this. Several candidates felt it necessary to redraw the table, possibly not understanding that they were simply required to complete the gaps in the printed table. Surprisingly, there were errors in finding the 1.6 and 3.2. Some candidates did not state 3.394 to three decimal places as requested.

(b) Many candidates showed an understanding of the trapezium rule. The most common errors were in finding the interval width; $\frac{20}{6}$ and $\frac{20}{2}$ were common mistakes. A few candidates thought that they needed to multiply their answer by 20 (the width of the river) to find the area.
Some candidates substituted x values rather than y values.
The false formula $\frac{20}{n}(first + last) + 2(sumofothervalues)$ was distressingly popular.

(c) Some candidates multiplied by 2^3, there was also a tendency to consider the width of the river in the calculation. Many candidates were unable to convert m/s to m/min. When the calculation was correct, candidates often missed the instruction to give their answer to 3 significant figures.
Many candidates completely missed the point of the question and found the volume generated when the section in (a) was rotated around the x axis.

Question 4

This question brought out the worst in some candidates' algebra.

(a) Despite a lot of fudging to get to the given answer, many candidates completed this successfully, although often using inefficient methods. Simply cross-multiplying the denominators led to a long quadratic numerator and a cubic denominator, which many then tidied up and factorised correctly. Most errors occurred when simplifying the numerator - quite a few candidates made a sign mistake when expanding the brackets and then tried to fudge the answer.
Some candidates split the first part of the question into partial fractions, and then the required answer fell out very nicely.

(b) Some candidates confused the inverse function with the first derivative or with the reciprocal of the function. Both re-arrangement and flow-chart methods were seen. The most common errors were a sign error in the final answer, or not completing the working to express the inverse function as a function of x.

(c) A few candidates combined the functions in the wrong order, but many made a correct initial step. Some candidates made the question more difficult than necessary by reverting to the unsimplified version of f(x). A surprising number of candidates did not simplify the denominator $x^2 + 5 - 1$ correctly. Popular alternatives were $x^2 - 4$ and $-x^2 - 5$. Many candidates lost the final mark for ignoring the possibility of x being -2. Another common error was to substitute $x = \frac{1}{4}$ into the combined function.
Some candidates never actually stated the combined function, they worked the problem in two stages, firstly finding $f^{-1}\left(\frac{1}{4}\right)$, then solving g($x$) = 9.

Question 5

For many candidates this proved to be the most testing question on the paper.

(a) This was attempted with some degree of success by most candidates and many scored full marks. Most errors occurred in squaring and simplifying y. Some of the integration was not good – candidates attempting to integrate a fraction by integrating numerator and denominator separately, a product by integrating separately and then finding the product, or a squared function by squaring the integral of the original function. In some cases candidates failed to recognise that 2/x integrated to a *log* function.

(b) Very few candidates knew the formula for the volume of a cone, so a further volume of revolution was often found. Candidates working with the incorrect equation for the line expended considerable time calculating an incorrect value for the volume. Many candidates produced answers that were clearly not dimensionally correct in (b), and hence lost all 3 marks. It was common to see expressions of the form "final volume = volume – area" or "final volume = volume – area^2"

Question 6

Most candidates were able to complete some, if not all parts of this question.

(a) Most candidates scored well, with an inability to differentiate log x being the most common cause of error. This part of the question was subject to a common misread of the function as $f(x) = 3e^x - \frac{1}{2}\ln(x-2)$. We often see candidates working without correct used of brackets, and here they saw brackets that were not present.

(b) Many candidates went on to use their answer from (a) to make a correct start here. The working should have been straight forward but was made difficult by several candidates. Many candidates managed to produce the correct answer to (b) from a completely wrong answer to (a)!

(c) This was well done - most candidates obviously know how to use the ANS button on their calculators. Many candidates who went wrong had either made rounding errors, or they had assumed that $e^{-1} = 1$ when making their first substitution.

(d) This part was found more difficult. Candidates who did use an appropriate interval did not always give the values of the derivative correctly (for example, we assumed that an answer of 2.06… was a misread of a value in standard form). Some candidates did all the working correctly but did not draw any conclusion from it. Many chose an interval that did not include the root or that was too wide. A significant number ignored the wording of the question and continued the iteration process.

Question 7

Most candidates tackled this with confidence (sometimes unwarranted).

(a) Many understood that the question required a translation by one unit, but this was frequently to the right rather than to the left.

(b) This was usually incorrect. The majority of candidates drew $y = |f(x)|$. It is difficult to say whether this was through lack of attention in reading the question or through a lack of understanding, but this is not the first time that the function $y = f(|x|)$ has been set.

(c) This was generally well done, although some candidates made heavy weather of substituting the *x* values into the modulus function, some clearly seeing the modulus bracket as a substitute notation for +/-.

(d) Some candidates drew themselves a new sketch and identified the required solution with apparent ease. However, many candidates appeared to have no idea how to solve an equation involving a modulus sign. A lot simply ignored the modulus sign; while others knew the solution involved positives and negatives, but appeared to scatter plus and minus signs randomly throughout their working.

Question 8

A few candidates offered no attempt at this question, but those who did attempt it seemed to score well.

(a) Many managed to expand the compound angles. Most seemed to be comfortable working with surds, and realised that $\tan\theta$ was obtained by dividing $\sin\theta$ by $\cos\theta$. A lot did get to a correct form for the answer, although there were many sign slips and errors in combining $\sqrt{3}$ and $\sqrt{3}/2$.

(b)(i) Many candidates produced very quick answers, although some could not progress beyond the initial statement $\cos 2\theta = \cos^2\theta - \sin^2\theta$.

(b)(ii) Most candidates made the link with the previous part and went on to form the required quadratic equation. Many seemed comfortable working in radians, although some worked in degrees and then converted their answers. Solutions outside the range were quite often seen, with $-\pi/2$ being particularly common.

Several candidates reached the stage $1-2\sin^2 x = \sin x$, but could make no further progress. There were also several spurious attempts to solve this equation in this form. Some candidates ignored the instruction "hence". A few of these were able to deduce the correct values for *x* by considering sketches of the functions.

(b)(iii) Many candidates produced very quick answers by looking at what they had shown in (b)(i), although in some cases after a page of work candidates had horrific expressions involving $\cot y$ and $\sec^2 y$. A number of candidates were not able to make progress because they did not attempt to rewrite $\tan y$. Some candidates resorted to showing that the relation was true for one of two specific values of y that they chose. There was a common misread in this part, with many candidates seeing $2y$ in place of $\sin 2y$.

Pure Mathematics Unit P3

Specification 6673

Introduction

Most of the candidates who had been entered for this paper were well prepared and they were able to demonstrate their knowledge and understanding on the range of questions asked. The standard of presentation of answers was good. The specification was well covered and the early questions were found to be straight forward and accessible. More problems were encountered on 5(b) and (c) and on questions 6 (vectors) and 8. These questions proved to be significant discriminators. There was no apparent evidence of shortage of time, but candidates need to allocate considerable time for question 8 and they did not always do so.

Report on individual questions

Question 1

Most candidates attempted parts a) and b) successfully, with the vast majority using the remainder theorem, and very few using long division. Many of them did not do part c) correctly. There seemed to be some confusion between the *factor* $(x - 2)$ and the *solution* $x=2$. A number of candidates found all the solutions of the equation doing an unnecessary amount of work for the one mark available.

Question 2

Generally most candidates knew the binomial expansion, with a few not including the correct powers of a. There was clear evidence of inefficient cancelling, and there were many long and inelegant methods, so that many candidates were unable to obtain values of a and n from the complicated cubic equation which they had found. Early simplification gave rise to a simple linear equation.

Question 3

a) This was a straightforward integration by parts, which was recognised as such and done well in general. The most common error was the omission of the constant of integration, but some confused signs and others ignored the factors of two.

b) This was done well by those students who recognised that $\cos^2 x = (1 + \cos 2x)/2$ but there was a surprisingly high proportion who were unable to begin this part. Lack of care with brackets often led to errors so full marks were rare. There was also a large proportion of candidates who preferred to do the integration by parts again rather than using their answer to (a).

Question 4

Part (a) was found to be easy by most candidates though some did give themselves extra work when finding the centre and radius of the circles, especially if they used the *f*, *g*, *c* method rather than the $(x-a)^2 + (y-b)^2 = r^2$ form of the equation of a circle. The diagrams were well drawn in part (b), with circles clearly in the correct quadrants and in most cases appearing to be the same size and to pass through the centre of the other circle. In part (c) many did not give exact answers, instead resorting to the calculator. The usual method of solution was algebraic rather than geometric.

Question 5

(a) Most understood the context of this problem and realised that they needed to use $t = 4$, although $t = 0$, 1 or 5 were often seen.

(b) Very few had any idea at all about how to differentiate V (many gave their answer as $-t(1.5)^{-t-1}$, or had a term $(1.5)^{-2t}$).

c) The comments made in answer to the request to interpret their answer to part (b) were usually too generalised and vague. The examiners required a statement that the value of $\frac{dV}{dt}$ which had been found represented the rate of change of value on 1st January 2005

Question 6

More success was achieved by those writing their vectors as column vectors rather than by those whose solution remained in terms of i, j and k. The common false statement $\begin{pmatrix} c \\ d \\ 21 \end{pmatrix} - \begin{pmatrix} 0 \\ 5 \\ 11 \end{pmatrix} = \begin{pmatrix} 2 \\ 1 \\ 5 \end{pmatrix}$ was clearly wrong as the k component did not match. Those who instead wrote $\begin{pmatrix} c \\ d \\ 21 \end{pmatrix} - \begin{pmatrix} 0 \\ 5 \\ 11 \end{pmatrix} = \lambda \begin{pmatrix} 2 \\ 1 \\ 5 \end{pmatrix}$, and found $\lambda = 2$ then easily obtained c = 4 and d = 7.

b) A variation of this question has been set several times over the past few years, but there were still a large proportion of candidates who could not get beyond a.b=0, or beyond $2x + y + 5z = 0$.

c) Even those who had found P frequently did not use the simple formula for the area, preferring instead ½*ab*sinC, but not specifying their *a*, *b*, or C. Again the use of 2i + j + 5k for the vector AB led to incorrect answers. Some students did not give their answers to the requested 3 s.f.

Question 7

This was well done on the whole but there were some slips simplifying the algebra in part (a) and a significant number of candidates persevered with complicated constants, involving π^2, throughout the question. The separation of variables and solution of the differential equation was answered well. In c) most candidates had some success trying to find their constants, but a number found the arithmetic difficult and did not obtain a correct answer.

Question 8

a) A number of candidates lost marks in this question. Some confused differentiation with integration and obtained a logarithm, others made sign slips differentiating y, and a number who obtained the correct gradient failed to continue to find the equation of the tangent using equations of a straight line.

b) There was a lack of understanding of *proof* with a number of candidates merely substituting in values. Better candidates were able to begin correctly but some did not realise that if the answer is given it is necessary to show more working.

c) Very few got this correct. There was a tendency to use parts and to be unable to deal with the integral of $\ln(2x–1)$. The most successful methods involved dividing out, or substituting for $(2x-1)$. Those who tried a parametric approach rarely recognised the need for partial fractions.

Pure Mathematics Unit P4
Further Pure Mathematics Unit FP1

Specification 6674 / 6667

Introduction

This paper proved to be very accessible and almost all the candidates were able to make some progress. The last three questions in particular proved to be a good source of marks for candidates of all abilities. The examiners were a little disappointed at the number of careless errors made and it was surprising, at this level, to see candidates trying to use the quadratic formula to solve the simple equations generated in question 6(b). Nevertheless the majority of candidates showed a good understanding of the techniques and topics on this specification.

Report on individual questions

Question 1

In part (a) most candidates were able to split the expression into partial fractions although sometimes poor factorization such as $4r^2 - 1 = 4(r - \frac{1}{2})(r + \frac{1}{2})$ let them down. A surprising number though did not use the method of differences to complete the proof. In part (b) the most common error was to omit the factor of $\frac{1}{2}$ resulting in an answer of $\frac{20}{861}$.
Some candidates could not handle the limits on the sum correctly and there were a number of cases of S(20) – S(11) rather than S(20) – S(10).

Question 2

Part (a) was usually answered well. The root 1 – 3i was identified as part of a conjugate pair and then a variety of methods were used to find the 3rd root. Forming a quadratic factor and using long division was a popular approach but a number used the factor theorem and the more astute spotted that the sum of the roots was equal to zero thus enabling them to write down the answer very quickly. Some candidates seemed unsure of the difference between a factor and a root. The sketch in part (b) was usually completed successfully, but when the three points clearly did not form a right angled triangle (as when $z = 2$ was given as the third root in part (a)) this did not seem to prompt candidates to check their earlier working. A variety of methods were employed to answer part (c) with gradients, the inverse of Pythagoras' theorem and the identification of two right angled isosceles triangles being the most common. A few candidates used the scalar product with a vector approach which worked well. Some candidates lost the final mark in part (c) because their proof was incomplete: assuming, rather than stating and justifying, symmetry was a common fault.

Question 3

This question was often answered well and the ideas behind the use of an integrating factor were well known. The correct integrating factor $(x+1)^2$ was commonly seen but some failed to multiply the right hand side of the equation by this factor correctly. The left hand side was usually simplified to $y\ (x+1)^2$ but there were sometimes long winded attempts to integrate the other side. These often involved using integration by parts and occasionally led to incomplete solutions. A surprising number lost the final mark for failing to divide their $+c$ by $(x+1)^2$.

Question 4

It was disappointing that in a question about numerical methods a number of candidates failed to give values to justify their statements. In part (a), for example, simply stating f(1.2)<0, f(1.1)>0 and f(1.15)>0 is not sufficient. However, apart from the small minority who worked in degrees, most candidates did evaluate the function at the appropriate points and were able to score well on this question.

The method of interval bisection was generally used correctly in part (a) although there were a number of candidates who used linear interpolation instead and wasted time and marks in the process. The differentiation in part (b) was usually correct, but sometimes the 1 did not disappear. The Newton Raphson technique was used efficiently and accurately. Most candidates were able to give a suitable interval in part (c) and the evaluations were often accompanied by a suitable comment to secure both marks.

Question 5

Most candidates knew that the argument of a complex number had something to do with the arctan function but few drew a diagram or knew how to obtain a value in the correct quadrant and this affected their answers to parts (a) and (c).

Part (a) was not answered well with few candidates having a correct strategy for obtaining an argument in the second quadrant. There were some alarming algebraic errors seen in part (b) and often these were not connected with the complex numbers but evidence of a poor grasp of the basic rules that should have been securely established at this stage; for example when $\frac{A}{2-\mathrm{i}}$ became $\frac{A}{2}-\frac{A}{\mathrm{i}}$. However a large number of candidates did multiply w by $\frac{(2+\mathrm{i})}{(2+\mathrm{i})}$ and often they knew how to find the modulus of a complex number and could use $|w|=\sqrt{20}$ to establish that $A = 10$ and hence find w. Some candidates multiplied w by $(2 - \mathrm{i})$ and then by setting the imaginary part to 0 were able to find w without needing to evaluate A.

In part (c) most used $\arg\left(\frac{w}{z}\right)=\arg(w)-\arg(z)$ and were able to make some progress, but a number preferred the longer method of finding $\frac{w}{z}$ in the form $a + \mathrm{i}b$ and then trying to find the argument of this complex number. Unfortunately these candidates often ignored any consideration of an appropriate quadrant for their argument.

Question 6

This question was a good source of marks for all the candidates.
Apart from occasional problems with curvature, the sketches in part (a) were good. Sometimes the sketch did not show that there were 4 intersections and this led to problems later in part (c).
Many candidates made heavy weather of part (b) trying to calculate each root from a separate equation rather than realizing that there were only two cases to consider. The usual crop of errors in algebraic processing spoilt some solutions here, but the majority was able to form and solve the appropriate quadratic equations and find the 4 solutions. Sometimes time was wasted by finding the y coordinates of the points of intersection of the curves.
Part (c) proved easy for those whose sketches clearly showed the 4 intersections but others struggled here and sometimes only gave one of the inequalities correctly.

Question 7

Nearly all the candidates were familiar with the methods for solving second order linear differential equations and the technique was clearly well rehearsed. There were several places where careless errors could be made and a disappointing number of candidates came unstuck here as their resulting expression for x made part (c) impossible.

The complementary function was usually found correctly and most went on to propose a suitable particular integral. Unfortunately careless substitution of $x = at + b$, often caused by $\frac{\mathrm{d}^2x}{\mathrm{d}t^2} = 1$, led to an incorrect general solution. Some candidates had difficulty with x as a function of t and worked with y and x, but those who gave their final answer as a mixture of functions of x and t had difficulties later on. The correct methods were nearly always employed in part (b), although a few candidates did just use their complementary function rather than the general solution, but careless substitution of $\frac{\mathrm{d}x}{\mathrm{d}t} = -1$, or earlier errors, meant that many did not reach the correct answer to part (b). Even those who had an incorrect version for x were able to start part (c) but they soon ran into difficulties when trying to solve $\frac{\mathrm{d}x}{\mathrm{d}t} = 0$. Those who had a correct expression were usually able to simplify $\mathrm{e}^{-\ln 2}$ to $\frac{1}{2}$ and complete part (c), arriving at the printed answer and showing that the second derivative was positive to establish that the answer was a minimum.

Question 8

This question was often answered very well. In part (a) the majority of the candidates were able to find the values of θ at *P* and *Q* and usually they were then able to prove the required result. There was some dubious trigonometry seen here, such as *OP* = 6*a* followed by *PQ* = $6a\tan\left(\frac{\pi}{3}\right)$, but many gave a convincing proof. A sizeable minority of candidates made the unwarranted assumption in part (a) that the tangent at *P* was parallel to the initial line, whilst this yielded a correct value for θ it did not, of course, receive any credit although such candidates were allowed to use their value in the following part.

In part (b) most tried integrating $16a^2(1+\cos\theta)^2$ and knew how to deal with the $\cos^2\theta$ by using the double angle formula. Most chose suitable limits but common errors were to use $\pi, \frac{\pi}{2}$ or $\frac{\pi}{6}$ instead of $\frac{\theta}{3}$. Some forgot to subtract the area of the triangle and a few only calculated the area above the initial line but, apart from careless slips, many candidates gave very good solutions.

Pure Mathematics Unit P5
Further Pure Mathematics Unit FP2

Specification 6675 / 6668

Introduction

This paper was found to be more challenging than previous ones. Candidates were most comfortable with questions 4 and 5. Those candidates unfamiliar with the use of half angles and/or double angle formulae techniques were particularly disadvantaged in questions 3, 6 and 7. Some candidates were unable to produce substantial solutions to questions 7 and 8 having spent too long on question 6, with little positive results. Candidates need to be aware that too much time lost in the middle of a paper can seriously effect their approach to subsequent questions, potentially losing accessible marks.

It was noticeable that sign errors in working prevented progress at critical stages throughout the paper, although the standard of algebraic working was generally excellent.

Report on individual questions

Question 1

This was a good starter question for most candidates. The popular method of approach in part (a) was to split the integral into two parts, with the majority recognizing the integrands. Candidates who made an initial substitution also fared well. Very few managed to complete the question by using the method of integration by parts. Candidates applied both limits in parts (b), although a substantial minority evaluated using degrees.

Question 2

Part (a) was very well done. A few candidates assumed it was necessary to derive an expression for $\cosh 2x$ by employing formulae such as $\cosh^2 x - \sinh^2 x$, making extra work for themselves, and, possibly introducing numerical errors. Many had problems dealing with $2x$ when differentiating in part (b); equations such as $f'(x) = p - \text{sech}^2 2x$ and $f'(x) = p - 2\text{sech}^2 x$ were frequently seen. Few of those who made a good start actually found a correct value for p, with a surprising number omitting to square their value of $\text{sech}2x$ as a final step in the evaluation. A minority did not differentiate $f(x)$ in part (b), trying to solve $f(x) = 0$ to find a value of p.

Question 3

Candidates gained high marks on this question with the vast majority successfully using the chain rule in the differentiation of x and y. Complete competence in finding the curved surface area was demonstrated by most with excellent concise solutions. Some who reached $\int 6\pi a^2 \sin^4 t \cos t\, dt$ went on to express $\sin^4 t$ as $(1-\cos^2 t)^2$, before attempting to integrate.

A few misunderstood the question and tried to find the area under the curve; others who made a correct statement $\int 2\pi y ds$, having dealt correctly with *ds,* forgot to include $\sin^3 t$ when substituting back in.

For some the limits caused difficulties with $\sin^5 a$ being included in their answer.

Question 4

Virtually all candidates scored high marks with good clear working in part (a) and generally only numerical errors in part (b). Most used the reduction formula given to evaluate I_0, I_1 and I_2. The quantity of brackets involved in linking all three often led to factors of 2 and sign errors being introduced at some stage.

A minority did not fully understand the use of limits in this context, applying them first to I_0 and again through their I_2 expression, thus losing $-\frac{1}{4}$ in their answer. Candidates who treated part (b) independently from part (a) integrated by parts twice. This proved to be a most efficient method, introducing few errors.

Question 5

Most candidates were familiar with this topic and high marks were scored. A few did not recognize the need to find the gradient at the specific point *P* in part (a), substituting their $\frac{dy}{dx} = \frac{2a}{y}$ as the gradient of the tangent, then on reaching $y^2 - 2apy = 2ax - 2a^2p^2$, replacing y^2 with $(2ap)^2$ to achieve the given tangent equation. Others quoted the tangent to a parabola equation without justification. Not all candidates appreciated the significance of the parameter 4*p* in part (b) , using $\frac{1}{p}$ as the gradient, producing a line parallel to the tangential line at point *P*. These candidates generally moved on to another question after failing to find a point of intersection in part (c). Those who treated their tangent equations as quadratics in *p*, tried to solve, resulting in a mammoth algebraic task.

There was a lack of understanding of the concepts of focus and directrix in parts (d) and (e). Many candidates drew two parabolas, but with one shifted and not going through the origin; others made no attempt at all. It was disappointing that so few could demonstrate any understanding of shape, failing to recognize that simply substituting $x = 0$ would ascertain that both parabolas passed through the origin. All too often those with two correct shapes mislabelled them.

Question 6

This question caused great difficulty to the majority of candidates. Those confident in integration usually chose a substitution method either initially or after one step of integration by parts and gained full marks. Others continued with integration by parts through several steps using incorrect integration such as $\int \sqrt{x^2-1}\ \ dx = \frac{(x^2-1)^{\frac{3}{2}}}{2x}$ before using the limits to magically reach the printed answer.

It was not uncommon to see pages of working with no progress and valuable time lost. Even those who did use valid methods to make some progress then jumped, without demonstrating the use of the limits, to state the printed answer. Candidates should be advised to stop to consider an appropriate method rather than rushing into copious working that leads nowhere.

Question 7

Most candidates made a good start to parts (a) and (b). Many were unaware that the half angle formulae were needed for both, generally reaching $\int \sqrt{2+2\cos t}\ \ dt$ in part (a) and $\frac{dy}{dx} = \frac{\sin t}{1+\cos t}$ in part (b), which proved to be their sticking point.

Part (c) was done simply and quickly by candidates who used $\rho = \frac{d(4\sin\psi)}{d\psi}$
Few candidates who used the formula book, managed to evaluate ρ, and κ was sometimes thought to be the radius of curvature.

Question 8

Scrappy untidy attempts at this question suggested a lack of time rather than a lack of knowledge. Part (a) was poorly done and many answers suggested incorrectly that $\ln\left(\frac{x}{y}\right) = \ln x - \ln y$ was sufficient to show the statement. Those who made a valid start to part (b) were generally successful. Stating $x = \frac{2}{e^x + e^{-x}}$ was not uncommon, with candidates continuing to solve for e^x in terms of x. It was surprising how many candidates were muddled with the hyperbolic formula connecting $\tanh x$ and $\operatorname{sech} x$ in part (c); $\tanh^2 x = \operatorname{sech}^2 x \pm 1$ was frequently seen. Candidates did not seem perturbed by producing $\ln(-ve)$ answers. Far too many replaced the hyperbolic functions by expressions in terms of e^x producing much working before realizing they were unable to solve their quartic equation. The format of the question indicated the preference to stay with trigonometric terms. It was unfortunate that good candidates assumed the demands in part (b) indicated there was only one solution in part (c).

Pure Mathematics Unit P6
Further Pure Mathematics Unit FP3

Specification 6676 / 6669

Introduction

The final three questions on this paper were easily accessible to the majority of candidates and many scored high marks on these. The first four questions were answered less well and were good discriminators between candidates. The parts of questions involving proofs and explanations were the least well done. Many candidates showed a lack of understanding of the nature of proof and gave insufficient details in answers to questions that required a given result to be shown. Another significant factor in the loss of marks was poor algebraic manipulation. Candidates clearly had time to complete the paper.

It would be helpful if all centres ensured that their candidates completed the grid on the front of their answer booklets to indicate which questions have been answered. It is also important that candidates fill in full details on all supplementary sheets.

Report on individual questions

Question 1

Completely correct answers were rarely seen. Many candidates calculated $u_2 = 5.024\ldots$ and indicated that this was greater than 5 rather than verifying for $n = 1$ by indicating that $u_1 > 5$. A significant number of candidates manipulated expressions for u_{k+1} or u_{k+2} but made no progress with the method of induction. Many candidates showed that they misunderstood the principle of mathematical induction by attempting to work from $n = k + 1$ to $n = k$ rather than the other way round. The final concluding statement (e.g. therefore true for all $n \in \mathbb{Z}^+$) was often missing.

Question 2

Completely correct answers were rarely seen. Many candidates did not give convincing explanations to given answers. Others tried long-winded manipulation of components of vectors or elements of matrices which were usually abandoned with no conclusions. Parts (a)(i) and (b)(i) were usually done successfully. In (a)(ii) some candidates lost both marks by omitting the vector product sign from $\mathbf{a} \times (\mathbf{b} - \mathbf{c}) = \mathbf{0}$. Others lost the final mark by not explaining the significance of this result. Marks were lost in (b)(i) by candidates who treated the given equation as algebraic and who either attempted to factorise or did not understand the importance of order in matrix multiplication. The most common errors in (b)(ii) came from candidates not appreciating that $\mathbf{A}$ was singular and attempting to find $\mathbf{A}^{-1}$ or from not knowing how to proceed from the two equations produced from the product of $\mathbf{A}$ and $\mathbf{B}$.

Question 3

The majority of candidates scored full marks for parts (a), (b) and (c). Part (d) was only answered correctly by the best candidates. Although many candidates were able to find equations in x and y, y and z and/or x and z, most were unable to use these to find the required vectors. Some candidates used a vector product to find the direction of the line but were then unable to make any progress with finding the position vector of a point on the line. It appears that candidates are less familiar with the equation of a line in the form $(\mathbf{r} - \mathbf{a}) \times \mathbf{b} = \mathbf{0}$ and many left their line in the form $\mathbf{r} = \mathbf{a} + \lambda\mathbf{b}$.

Question 4

Most candidates drew a circle in part (a), although a significant number drew a circle with centre 0 –3i. It is not necessary to use graph paper for a sketch and some of those who did lost marks because they gave no indication of scale.

Very few candidates drew a half-line for part (b). This might have prevented many from giving an incorrect answer with $\text{Re}(z) > 0$. Those candidates who used an algebraic method resulting in a quadratic equation often made errors either by giving two answers and not considering which should be rejected or by only considering one solution (usually $2x^2 = 9$, therefore $x = \frac{3\sqrt{2}}{2}$).

Part (c) proved difficult for the weaker candidates who were unable to deal with a factor of i. It was very rare to see a solution that used $|\,\mathrm{i}\,| = 1$ in order to work towards the form $|\,w - a\,| = |\,w\,|$. Most worked with $w = u + \mathrm{i}v$ or $z = x + \mathrm{i}y$ and most errors involved poor algebraic manipulation or an incorrect use of modulus such as $|\,a + \mathrm{i}b\,| = a^2 - b^2$ or $|\,a + \mathrm{i}b\,| = 3 \Rightarrow a^2 + b^2 = 3$.

Question 5

Many correct solutions to part (a) were seen, including the use of $\sinh \mathrm{i}n\theta = \mathrm{i} \sin n\theta$. It is important that candidates understand the particular need for clarity and for sufficient working in a ‘show’ question. Common errors in part (b) included the use of $\left(z + \frac{1}{z}\right)^5$ and poor algebraic manipulation. Candidates who started with the expansion of $(\cos \theta + \mathrm{i} \sin \theta)^5$ rarely achieved more than two marks. Although many candidates identified the correct equation in part (c), the solutions of $\sin \theta = 0$ were frequently ignored. The equation $\sin^4\theta = \frac{1}{4}$ was often solved incorrectly, with the most common errors occurring when candidates ignored the solutions of $\sin \theta = -\frac{1}{\sqrt{2}}$.

Question 6

A substantial number of candidates scored full marks for this question. Incorrect algebraic manipulation accounted for most of the errors in (b). The candidates who wrote two separate equations in the form $y_1 \pm y_{-1} = k$ were more successful than those who tried to substitute one approximation into the other before putting in known values. A few candidates proceeded to find y_2; others tried to use the original differential equation with mislabelled values.

Part (c) was generally well done by candidates who differentiated using the given form. Those who made $\dfrac{\mathrm{d}^3y}{\mathrm{d}x^3}$ the subject of the formula and used the quotient rule were less successful. It was not uncommon to see $4(1 + x^2)\dfrac{\mathrm{d}^2y}{\mathrm{d}x^2}$ written as $4\dfrac{\mathrm{d}^2y}{\mathrm{d}x^2} + x^2\dfrac{\mathrm{d}^2y}{\mathrm{d}x^2}$.

Parts (d) and (e) were usually well done. Common errors included taking y_0 as 0 and missing out factorials. Candidates should be advised to use their formulae books in order to avoid these types of errors.

Question 7

This question provided a successful end to the paper for many candidates. Wrong answers to parts (a) and (b) were rare and (c) and (d) were usually well done. Those candidates who used $|\,\mathbf{A} - \lambda\mathbf{I}\,| = 0$ in part (c) rarely gained two marks. Few found the correctly factorised cubic equation and those who found $\lambda = -1$ rarely justified that this was the required eigenvalue. Most candidates were able to find equations in x, y and z in part (d). Mistakes were rare; the most common being the use of $\mathbf{A} - 8\mathbf{I} = 8\begin{pmatrix} x \\ y \\ z \end{pmatrix}$ and using $x = 2y = z$ to give an eigenvector in the form $k\begin{pmatrix} 1 \\ 2 \\ 1 \end{pmatrix}$.

Mechanics Unit M1

Specification 6677

Introduction

The paper was found to be very accessible by candidates, with enough on the paper to enable candidates to demonstrate their abilities. There was no clear evidence of time being a problem with 8 questions on the paper. A number made no attempt at question 8 at all, but often this seemed to be weaker candidates who perhaps found the whole topic of vectors difficult.

As always, vector work was found to be difficult for many candidates. On this paper, the question explicitly set in vector form, qu. 8, proved to be discriminating for many in making fairly clear who really understood the principles involved and who did not. However, as in previous years, the understanding of quantities such as velocity. momentum, impulse as essentially vectors was also sometimes not strong, with candidates failing to deal adequately with the signs involved in the relevant one-dimensional problems (cf. below on qu. 2).

The issue of giving answers to an 'appropriate' degree of accuracy continues to be a problem for many candidates. If working with a problem where a value of g as 9.8 m s^{-2} has been used, candidates are expected to be aware that giving answers to large numbers of significant figures is 'inappropriate'. The policy of the board is to accept answers to 2 or 3 s.f. in such cases, but answers to 4 or more s.f. will be penalised (by one mark per question). In other questions where approximate answers are to be given, an accuracy of 3 s.f. is encouraged. Many thus lost a mark e.g. in qu. 4 (a).

The standard of presentation in answers was fair, and slightly better than in some recent exams; however, many do still present their work very unclearly and at times it was difficult for examiners to follow the stages of the solutions being presented. This was particularly noticeable in qu. 8 (d) where, as often as not, a mass of brief calculations were scattered over the page with an answer mysteriously appearing at the bottom! It is too important for candidates to draw their own diagrams, even where a diagram is given on the question paper, especially in instances where the forces concerned may change from one part of the question to the next (e.g. here in qu. 6). The situation in this respect seemed better than in some previous years, but it is a point which needs continually stressing that candidates who draw their own clear diagrams benefit themselves significantly.

Problems arising from candidates offering solutions to questions outside the allotted space seemed less this year. However, it is important to make clear to students the importance of this in the context of scripts being scanned electronically. The space given for solutions was very generous again this year, and most managed to keep within the allotted space, even when crossing out a first attempt and starting again. But a few do insist on giving their solutions to one question in a space reserved for answers to another one! This does create confusion, and in such circumstances candidates should be encouraged to use an extra sheet or paper, rather than stray in the space for another question's answer.

Report on individual questions

Question 1

The question was generally well answered, though by no means fully correctly by all. Some launched straight into using their standard equations without quite understanding the actual situation: e.g. a number found only the distance AC, failing to deduce the distance BC; and some appeared to assume that the point C was beyond the end B of the runway. However, most could make good progress with most of this question. It was also slightly disappointing to see a number of candidates unable to handle accurately the units involved, e.g. taking 1.2 km as 1.2 m.

Question 2

The relevant principles here were well known: virtually all candidates could apply the law of conservation of linear momentum in part (a), and could find an impulse in part (b) by attempting to find the change in momentum of one particle. Problems usually arose in relation to the signs of the velocities in question and some weaker candidates evidently failed to realise that, in their standard formulae such as '$I = mv - mu$', the velocities concerned are velocities not speeds and hence could have negative values.

Question 3

This question proved to be more of a discriminator. In part (a), most appeared to realise that they should be trying to resolve horizontally (though they did not always say so!), but even here there were some errors in the trigonometry. There were also some confused attempts at 'triangle of forces' approaches, though as often as not confusing a possible triangle of forces with the triangle in the given diagram. In part (b) only the better candidates realised that the tension in the same throughout the string and those who did not realise this could make little progress. Some ignored one part of the string completely; others took the tension in the vertical part to the vertical component of the tension in the sloping part.

Question 4

In part (a), most obtained $R = 2g \cos 20$ correctly; however, a large number failed to give their answer to an 'appropriate' degree of accuracy (here at most 3 significant figures), thus losing a mark. In part (b), most realised that the frictional force was equal to μR; but there was a surprisingly high number of errors in attempting to write down the equation of motion with several omitting a force (e.g. the component of the weight) in their equation; others appeared to be very confused with what 'F' was, using the same 'F' in both '$F = ma$' and '$F = \mu R$'. The figures involved were also quite sensitive to the accuracy presumed, and premature approximation led to a number of incorrect answers. Candidates should be aware that, if they give a final answer to 3 s.f., then they must work with previous values which are accurate to at least 4 s.f.

Question 5

Some very good answers were seen to this question with many fully correct (or all but correct) answers. Nearly all could draw a good sketch for the speed-time graph, with values appropriately put on the axes. A few made errors in part (b), finding only the area of the triangle under the speed time graph for that section of the motion, though many then recovered and correctly answered part (c). A few incorrectly assumed that the deceleration in the final part of the motion was the same as the deceleration in the first part. Generally though it was very pleasing to see this part of the syllabus so well mastered.

Question 6

Part (a) was generally well done, though there were still some answers given attempting to equate forces with moments. In part (b), quite a number of fully correct solutions were seen, though sometimes with not the most economic approach to the problem: some took moments about two different points which led to a fairly messy set of simultaneous equations to have to solve. Taking moments once, and resolving vertically, led to a much quicker solution! For those who went wrong (apart from making small slips processing equations), the most common error was to assume that the reactions in (b) had the same value as that found in (a).

Question 7

Candidates found this question more challenging and fully correct answers to all parts were not so common, though many could make good progress with some parts of the question. In part (a), many could do this correctly, and many this time did adopt the approach of considering the whole system (car + trailer together) to obtain the acceleration correctly. Considerably more problems were found with part (b) and only the best candidates seemed able to work out correctly the relevant forces acting on the car or the trailer. Many simply ignored the fact that the tension was acting at an angle and so failed to make any attempt to resolve it. However, many managed to recover well and produce correct answers to part (c) where it was pleasing to see so many correctly coping with the changed situation in terms of the forces. A common error was to assume that the acceleration found in (a) was now the deceleration of the car on its own. In part (d) a number of well argued answers were given, explaining that the normal reaction increased. Some however gave totally irrelevant reasons (e.g. that the friction changed, or that the weight remained constant and hence the normal reaction remained constant). This part again proved to be a good discriminator for more able candidates.

Question 8

The question proved again to be a good discriminator. The calculations involved were relatively simple, though a correct solution did require a proper understanding of the physical situation. Part (a) was generally well done, though not universally: some evidently did not know the meaning of the word ‘speed’. Part (b) was mostly correct. In part (c) a significant minority equated the **j** components, rather than the **i** components. In part (d), many got to the end result, apparently correctly, though the working presented often proved to be very challenging to decipher. Others used the wrong vectors or distances involved. In part (e) presentation was again somewhat inadequate, with some effectively stating one of the assumptions (e.g. the field being smooth), rather than saying that the opposite would be a factor needing to be taken into account (i.e. friction). Again some relevant responses were given, but also a number of irrelevant (or unclear) ones.

Mechanics Unit M2

Specification 6678

Introduction

The paper proved to be accessible to the majority of candidates and able to be completed in the time allowed. The questions which provided the best source of marks were questions 1 and 3 and those that proved to be the most demanding were 4(b), 5(b) and 6(b) and (c). The standard of presentation was very variable and some candidates did penalise themselves with some very poor diagrams, often in questions where a good diagram was the key to a good solution. Many candidates continue to throw marks away by not following the principle that if a numerical value of g (i.e. 9.8) is used in a calculation then the answer to that calculation should be given to 2 or 3 significant figures - more accurate answers will be penalised.

Report on individual questions

Question 1

This proved to be an easy starter for most and full marks was often seen. A few dropped a mark for giving an overaccurate answer in part(b).

Question 2

Many treated the framework as a lamina and lost several marks in the first part, although most knew the correct method. Of those who correctly treated the problem as a framework, a few tried to use three sides of a square and two sides of a triangle and made errors locating the appropriate centres of mass. Many candidates wasted time finding the distance of the centre of mass from BC. In part (b) there were some good solutions but many were unable to deal correctly with the introduction of M into the question.

Question 3

There were many fully correct solutions but there was some sloppy use of vector notation and also evidence of poor algebra. Most knew that they needed to differentiate but some lost the **i**'s and **j**'s. Others, in (a), were unable to deal with the magnitude correctly and simply put 15 = -9 + c. In the second part many unnecessarily went on to find the magnitude of the acceleration.

Question 4

Part (a) was generally well done although a significant minority used 10 cm instead of 0.1 m and were not put off by the fact that this meant that the darts player was throwing darts at a board which was 18 m away! The second part proved to be more challenging. Most tried to work from 1st principles and set up two equations and eliminate t but a few successfully used quoted formulae for the range or the equation of the path. Candidates are reminded that in this case if they misquote formulae they will lose all of the marks.

Question 5

The method in part (a) was generally well known and there were many good solutions. However, the second part proved to be more challenging with only the better candidates able to set up and solve their equations correctly and even then not all were able to pick up the final two marks - many only considered a further collision between B and C, which was impossible, instead of between A and B.

Question 6

This question caused considerable difficulty, even to the better candidates. There was much confusion about what forces were acting where – particularly at the hinge A and at the point D. Some were able to find the thrust in (a) by taking moments about A but often forces were omitted or extra ones included and final answers were rarely given to the appropriate accuracy. The second part was also poorly done with many candidates simply giving either the horizontal or vertical component only. There were very few convincing solutions to part (c), with many simply assuming the answer rather than showing it.

Question 7

Part (a) was usually correct, although a significant number failed to round their answer correctly, and most were able to pick up two out of three marks in the third part. Success in the other two parts was mixed - those, in part (b), who used $v^2 = u^2 + 2as$ to find the acceleration and then resolved along the plane were usually successful; those attempting to use energy were generally less successful often because of missing or extra terms in their equation. Part (d) was very straightforward for those who realised that the acceleration would be the same as in part (b) and simply used $v^2 = u^2 + 2as$ again with $u = 2$ to obtain the answer. For those who tried to use energy it proved to be much more challenging, again usually due to missing or extra terms in their equation.

Mechanics Unit M3

Specification 6679

Introduction

This paper proved demanding for many candidates and the quality of scripts seen varied widely. There were many excellent scripts, showing a thorough grasp of the principles of mechanics, but, given that this is a relatively advanced A2 module, there were also a surprising number of scripts submitted which showed very little knowledge of any of the mechanical ideas specific to this module. There was a substantial body of candidates who seemed much stronger, or more practiced, in Pure Mathematics than in Mechanics. These often gained excellent marks on the last two questions but could gain few marks when, for example, the application of ideas involving energy were required. There was very little evidence of shortage of time and many candidates scored the bulk of their marks on the last three questions on the paper.

Report on individual questions

Question 1

Nearly all candidates could apply Hooke's Law successfully, although a few confused this law with elastic energy. Virtually all candidates then knew how to use Newton's Second Law to complete the question but many failed to realise that a spring under compression produces a thrust and is not in tension. The majority of candidates did not give their final answer to an appropriate degree of accuracy. In questions involving a numerical value of g, answers should be given to 2 or 3 significant figures. Despite these comments, the great majority of candidates gained at least 4 of the 6 marks available for this question.

Question 2

Part (a) was generally well done and the majority of those who could not obtain the printed answer usually failed through lack of knowledge of the formula for the surface area of the sphere. This formula is given in the Formula Booklet and candidates in Mechanics are expected to be familiar with, or know where to look for, Pure (or Core) Mathematics formulae which are appropriate to a Mechanics module. Part (b) was generally poorly done. Many candidates were unable to visualise the situation and, after a few attempts to draw a diagram, abandoned the question. The simplest solution is to take moments about the point of contact with the floor or about the centre of the plane face of the hemisphere but this was rarely seen. The most successful candidates tended to be those who worked out the position of the centre of mass of the hemisphere and particle combined, even though this involved more work.

Question 3

This proved the hardest question on the paper and many scored no marks. The use of energy was seen more frequently than approaches using Hooke's Law and an equation of motion, but energy was not well handled. There are four elastic energies involved in the question; two different energies in the initial position and two identical energies at the mid-point. It was common to see three of these four energies omitted. When it was realised that there were two energies at the mid-point, it was not unusual for candidates to think these "cancelled" out. Those using Hooke's Law again often only had one string in tension and no credit can be gained using SHM methods unless a variable extension is used. With the SHM method, candidates often had difficulty finding the extension of the two strings but, on balance, this method tended to be used more successfully than energy. It is worth recording that a few candidates produced completely correct solutions, using Newton's Second Law, measuring the displacements from A, B or the initial position of P. They then used methods of solving second order differential equations to complete the solution without reference to SHM or any further mechanical principles. This module is probably now taken by a high proportion of candidates who have studied Further Pure Mathematics and such solutions may be more commonly seen than in the past. Questions requiring explanation remain unpopular with candidates. In this case, the comments expected were that the maximum speed occurs when the acceleration is zero and the mid-point is the position of equilibrium and, hence, the acceleration there is zero.

Question 4

Although the general principles involved in this question were usually well understood, many errors of detail were seen. Many assumed r to be the radius of the circle rather than the sphere. This led to an incorrect angle in (a) and a significant oversimplification of the question in (b). A common error in (b), even among those who realised in (a) that r was the radius of the sphere, was to fail to calculate the radius of the circle. Almost all of those who could find the angular velocity knew how to convert this to the time for a complete revolution.

Question 5

Part (a) was well done with the printed answer enabling many candidates to correct incorrect signs. In such questions the examiners require the clear use of the principle of conservation of energy and the constant acceleration formula $v^2 = u^2 + 2as$ is not accepted, as it stands, without some evidence that kinetic and potential energies have been used.

In part (b), a few thought that the particle left the sphere when the velocity was zero but the majority realised that the normal reaction between the sphere and the particle was zero and, apart from some confusion which was not infrequently seen between θ and α, could complete the question.

In part (c), there was a fairly even split between those use energy and those using projectile methods. The easiest solution, using conservation of energy from the initial position, was not often seen but, when it was, it was almost invariably completely correct. The projectile solutions were longer, harder and less frequently correct. Those using projectile methods often dealt only with the vertical component of velocity.

Question 6

Some candidates had difficulty in interpreting this question with candidates being confused between clock time and elapsed time or between the depth of the water and SHM displacement. A few did not understand the 24 hour clock and thought there were six hundred hours between low and high water, despite the question specifying that the times were on a particular day. In part (a), the indirect method of finding x first and then using $v^2 = \omega^2\left(a^2 - x^2\right)$ was more popular than using the differentiation method but those who chose the latter almost always obtained the correct answer. Many thought the period of motion was six rather than twelve hours. However there were many good solutions to this questions and it was pleasing to see answers clearly explained through sketches or graphs. In part (b), most could find a value of the time when the depth of the water was 5.5m but not all could interpret this correctly and complete the question.

Question 7

For many, this proved the easiest question on the paper and full marks were common. The most frequently seen error was the omission of the minus sign when setting up the initial differential equation. This produced the wrong value of k but did in fact give the correct relation between v and x, $v^2 = \dfrac{36}{x+1} - 2$, and this was followed through for full marks in part (b). The commonest manipulative error seen was the incorrect integration of $\dfrac{k}{\left(x+1\right)^2}$. A few candidates used definite rather than indefinite integration. These tended to be very well prepared candidates and they nearly always gained full marks.

Mechanics Unit M4

Specification 6680

Introduction

The paper proved demanding for many candidates and although marks in the 40 – 60 range were common, few were able to score above 65. Questions 3 and 4 provided a good source of marks, even for weaker candidates. The questions which caused the most problems were 1(b), 5(a), the last part of 6(a) and 7. The overall standard of presentation was poor.
Clear diagrams, drawn in pencil so that corrections could be made easily, were the exception. In many cases no diagram at all was used and symbols were not defined, it being left to the examiner to work out what the candidate intended. Candidates should be reminded of the advice on the front of the paper to 'make their methods clear to the examiner'. It is also helpful if candidates start each question on a new double page – a 16 page answer book should not have all the questions answered in three or four pages with minute script and double column working, leaving the majority of the booklet empty.

Report on individual questions

Question 1

(a) Candidates could usually draw the plane as described but often misplaced the angle α between the vertical and the normal to the plane. Many candidates drew the problem with the plane horizontal or used components in undefined directions leaving it to the examiner to work out what was intended.
Finding components along and perpendicular to the plane was attempted by most candidates and those who squared the components to find the resultant were usually more successful than those who tried to find the angle to the plane at which the ball rebounded.

(b) This part was very badly done. Most candidates did not use components of the velocity perpendicular to the plane using instead the initial and final speeds of the particle. Candidates who realised that components were needed often failed to take into account the directions involved resulting in an answer of 2Ns rather than 6Ns.

Question 2

This relative velocity problem was not well done. A clear diagram with all velocities shown and with $\underline{v}_Q$ perpendicular to ${}_P\underline{v}_Q$ were rare. The entire problem was frequently reflected about the North-South axis leading to an answer of 300°.
Candidates who attempted a vector expression of the problem and the use of a dot product made some progress but often failed to complete the problem. Very few candidates gave the complete three figure bearing 060.

Question 3

This was a standard question which most candidates were able to complete successfully. It was disappointing to see so many solutions in which the given problem was forced to conform to a known model solution by reflecting the whole problem or by reversing some components and treating them as negative.
Candidates who used components along and perpendicular to the line of centres without resolving initially and then used expressions for $\tan \alpha$ and $\tan \beta$ produced the most elegant solutions.

Question 4

This was a standard problem on which most candidates scored well. Common errors involved incorrect signs in the integration or the omission of a factor of *k*. The constant of integration was not included in some cases but on the whole the question was well done.

Question 5

(a) Candidates found it difficult to draw a clear diagram with the angle θ correctly placed. Many candidates failed to see that the triangle PBC was isosceles and so used the cosine rule to find PC which resulted in many errors. Trigonometric manipulation was not well handled.

(b) This part of the question was answered much better than the first part. Most candidates knew the required method and obtained correct solutions although $\theta = 0$ was often omitted on the wrong grounds that the string was slack. Another error was to give only $\theta = \pi/3$ and to omit $\theta = -\pi/3$.

Question 6

(a) Candidates who drew clear diagrams of at least one of the two situations were often able to produce good solutions using the sine rule or by equating components in the North-South direction. Some solutions were marred by the use of approximations for the angle which did not lead to an accurate value for $\tan\theta$ ($\tan 53.1° \neq 4/3$) Two clear diagrams or convincing manipulation of inequalities were needed for completion of this part of the question but fully correct solutions were rare.

(b) The simplest method of using components in an East-West direction produced correct solutions for many candidates but a variety of other methods involving calculation of angles and the use of the cosine rule were attempted with varying degrees of success.

Question 7

(a) Fully convincing explanations of $x+y=Ut$ backed up with clear diagrams and the use of the length of the string in an equation for the distance travelled by the free end B of the string were rare.

(b)The lack of a clear diagram caused most candidates to fail to see that the displacement of the particle was y and hence its acceleration d^2y/dt^2. Candidates starting with the acceleration as d^2x/dt^2 usually only scored one mark for the tension in the string.

(c)Most candidates knew how to solve this standard problem but only a very few did so completely correctly. The auxiliary equation was used but frequently the solutions were wrong; $\omega$was omitted or an arithmetic mistake made. Few candidates seem able to complete the square quickly and accurately. The complementary function was usually correct but in some cases no or only one arbitrary constant was included. Most candidates realized that the particular integral should be found at this point in the solution but some attempted to apply initial conditions before finding the particular integral thus obtaining wrong values throughout. Attempted particular integrals were often unnecessarily complicated involving t and t^2. The initial condition $dx/dt(0)=U$ was replaced by $dx/dt(0)=0$ by many candidates thus spoiling otherwise correct solutions and even candidates using the correct initial condition often failed to get the simple algebra correct to produce the required solution.

Mechanics Unit M5

Specification 6681

Introduction

The paper was accessible to the majority of candidates and seemed to be of an appropriate length. The most challenging questions were Q3 and Q7 with all the others proving to be good sources of marks. Many candidates had a good grasp of the basic principles of mechanics and the standard of integration required for the paper was generally very good. The standard of presentation was good but it would be helpful if candidates were encouraged to begin each question on a new page. In several centres, candidates failed to complete the grid on the front of the booklet with their question numbers in the correct order – it would be helpful if invigilators were asked to ensure that this was done at the end of the examination.

Report on individual questions

Question 1

Some candidates were unable to find the two forces in vector form but then went on to use a scalar product correctly. There were many fully correct solutions.

Question 2

Candidates using an integrating factor were usually successful and many gained full marks. Two other methods were seen – splitting the differential equation into two components and using a complementary function and particular integral. Correct solutions were sometimes seen but many of these candidates failed to use the initial conditions properly leading to incorrect constants.

Question 3

Nearly everyone gained the first two marks but correct solutions to part (b) were very rare. Most candidates did not know how to derive an equation for the equivalent systems of forces – they knew that a vector product was required but could not combine all the relevant terms correctly, omitting either the couple or the moments of the original two forces. Those who took moments about (1,1,1) saved themselves some time.

Question 4

This proved to be the most straightforward question on the paper with many fully correct solutions. The majority found the moment of inertia of the body correctly – the error for the minority was to use the moment of inertia of the disc about an axis through the centre rather than about the diameter. In part (b), a few candidates thought that energy was conserved, rather than angular momentum.

Question 5

Better candidates did very well in this question but others had a general idea of the methods but could not implement them correctly. The most common errors were: in (a), not using the motion of the centre of mass and using $Y - mg\cos(\pi/3)$ instead of $Y - mg$. and in (b), omitting the negative sign in the equation of motion. Candidates should not quote the formula for the period of oscillation – they should always work from first principles.

Question 6

In part (a), many candidates proved the result correctly, deriving the result from first principles as required. Those who did not either omitted terms or confused signs, writing δm instead of $(-\delta m)$ and $dm/dt = \lambda$ (but then writing $m = M - \lambda t$ since that was in the given answer) In part (b), since the differential equation was given, candidates were able to progress and the standard of integration was pleasing, with many correct solutions seen.

Question 7

Part (a) proved to be beyond the majority of candidates. The proof was not well known and most candidates could not find the moment of inertia of an elementary strip. Use of the parallel and perpendicular axis theorems was needed but they were rarely seen. However, marks were gained in (b) and (c) since the inertia was given although candidates often lost marks because they used mgh instead of $2mgh/3$ in the potential energy term and in the angular equation of motion.

Mechanics Unit M6

Specification 6682

Introduction

The paper proved to be quite demanding. Some excellent scripts were seen; but also there were a number of candidates entered for the exam who failed to show good understanding of many of the principles involved and seemed to be inadequately prepared for this module. There was no clear evidence that the paper was too long and most appeared to be able to complete all that they could on the paper. Presentation of work was generally reasonable, though some candidates did themselves no favours by failing to set out their working and their methods clearly.

Report on individual questions

Question 1

The question proved to be a considerable test about whether candidates fully understood the relevant mechanics and kinematics. Quite a number simply wrote down '$J = mv$' somewhat mechanically, failing to take full note of the fact that there were four rods and the total mass was $4m$. Only the best candidates realised that the linear velocity of the frame and the motion of the mid-point of BC due to the angular velocity were perpendicular to each other: many simply added their 'v' to their '$a\omega$'.

Question 2

The majority of candidates could make good progress with this question, writing down the relevant equations for the linear and angular motion of the sphere. Most also used the correct formula for the moment of inertia of the hollow sphere. The most common error was to assume that the friction was of limiting value, taking $F = \mu R$, rather than $F \leq \mu R$, with then an unpersuasive argument trying tot derive the given inequality for the answer from an exact value of μ.

Question 3

This question proved to be the most accessible on the paper, with many gaining full marks without too much difficulty. A few illegitimately assumed that the ball reached the wall at its highest point, but generally this question was very well answered.

Question 4

Some very good answers were seen here by those who could make good attempts at finding the speed of the particle at the general point (or at the point where it leaves the curve). Most could write down the relevant equation involving Newton's second law, and further progress was then usually dependent on knowing how to find the speed.

Question 5

Part (a) was generally well done, though sometimes presentation of working was somewhat cryptic and unclear. In part (b), some elementary errors occurred in setting up the initial differential equation (e.g. omitting the mass, or omitting a negative sign to take account of the fact that **F** was directed towards, not away from, *O*). The final answer came out fairly easily if the working was all correct; and hence early errors often led to complicated quadratics to try to solve which led to some loss of time.

Question 6

Part (a) was generally well done with many correct answers seen. In part (b), most could attempt to use the correct formula, but many omitted to multiply by a factor of $\mathrm{d}\theta/\mathrm{d}t$ when working out $\mathrm{d}^2r/\mathrm{d}t^2$. In part (c), many illegitimately assumed that, since the magnitude of the transverse component of the velocity was constant, the transverse component of the acceleration was also zero. The final parts of the question were rather dependent on previous correct working, and hence those who had made earlier mistakes could make little progress here.

Statistics Unit S1

Specification 6683

Introduction

There was some evidence that candidates had insufficient time to complete the paper, but there was also evidence that many of them were not sufficiently well practised in parts of the specification. Probability and use of the Normal tables are just two examples.

Candidates still lose marks because they do not do the simple things well. Far too many did not label their axes or show their calculations in question 4. Accuracy was not as much of problem this year since many candidates were aware of the need to give their answer to 3 significant figures, but there were still many who did not realise the need to consider accuracy.

Report on individual questions

Question 1

Most candidates were able to match the given values of the product moment correlation coefficient with the correct diagram. However, relatively few were able to give acceptable reasons based upon correlation rather than regression considerations. Even those candidates who correctly referred to variables increasing and decreasing missed identifying u, v and s, t or found it difficult to describe diagram B. There was a tendency to write about the points being in the middle of the diagram without reference to their randomness or scattering.

Question 2.

It was very disappointing that so few candidates could carry out a simple analysis of a set of data. Few scored well.

(a) Relatively few candidates were able to state, "distance is a continuous variable." The most common wrong answer in this part referred to the unequal class widths.

(b) In general frequency densities were well done. The most common mistake was to calculate the incorrect class width, taking the first class width as 4. Other mistakes were class width divided by frequency or frequency multiplied by class width although these were less prevalent than in previous examinations.

(c) Interpolation was not familiar to many candidates. Those pupils who did attempt to interpolate to find the median and quartiles were on the whole successful, common errors being the use of 50 instead of 50.5 or the wrong class interval. Many used the mid-point of the class for the quartiles or more frequently used 134/2 or (134 + 1)/2 as their responses for an estimate of the median.

(d) The mean was calculated successfully by the vast majority of candidates with only occasional error through using the sum of fx^2 as opposed to the sum of fx. The standard deviation proved more difficult – where students used the wrong formula, omitted the square root or lost accuracy marks through using the rounded value of the mean. Some candidates wasted time by recalculating the values given.

(e) Those candidates with sensible values for their quartiles managed to substitute successfully to calculate the coefficient although it was surprising how many could not get 0.14 from a correct expression. On the whole they drew the correct conclusion about the data being positively skewed, although a small number of candidates managed a correct calculation and then concluded negative skewness.

(f) Although a fair number of students could give a reason to confirm that the skewness was positive, most lost this mark by not justifying their comment using numerical values.

Question 3

Candidates were well prepared for this question. The major problems arose as a result of rounding. The most surprising was rounding to 1 significant figure! This came up a great deal too frequently. It should be established now that there is a need to keep values for a and b un-rounded when 'decoding' the line but to express answers to 3 significant figures in the final stages.

Question 4

(a) The vast majority of candidates were able to make an attempt at drawing a box plot though labels were not always added and the upper whisker often extended to 63. For many candidates this was the only mark they obtained for the question. Few candidates bothered, or were able, to use the information regarding 1.5 IQR in order to identify the limits of acceptable data. Of those candidates who did show some working more often than not, they did not do so in enough detail. The number 24 was usually implied but candidates often ignored showing working for the lower end. The numbers of 52 and -12 were visible on a number of papers, but the conclusion about which numbers were outliers was often omitted.

(b) The majority of candidates recognized positive skewness, but many did not justify their answer numerically. Some candidates did not understand the request about the "distribution of delays" and gave an interpretation more suited to part (c).

(c) Most managed a comment on the distribution that was relevant, but few wrote in terms of whether passengers would be bothered by the delays – the majority of students used technical statistical terms, referring to quartiles and percentages of the data, rather than simply interpreting the data in non-technical language.

Question 5

Generally this question was tackled well and there was much evidence of effortless solutions.

(a) Most candidates realised that the probabilities must sum to 1 and managed to use the split definition of the probability function well. Occasionally candidates failed to use both parts of the function and focused on just kx to get a value of a sixth, or more often through incorrect calculation and ignoring the (k+1) gained a value of k = 1/15.

(b) Usually well answered, but some candidates failed to recognise the demand for an exact value and proceeded to write down an approximate equivalent decimal.

(c) This part of the question was well answered. Although a minority of candidates failed to give their answer to 1 decimal place.

Question 6

(a) This part of the question was generally well answered, with only a few candidates attempting to standardize with 3.5^2 or $\sqrt{3.5}$. Some candidates were unable to calculate the required probability once 0.9236 had been obtained. Occasionally a truncated value of
$z = 1.42$ resulted in the final accuracy mark being lost.
(b) Many correct solutions were seen here.
(c) The majority of candidates seem to be unaware of the use of the percentage points table, and it was relatively rare to see $z = -0.5244$. The common errors were to use the tables incorrectly and use a value of 0.6179 or simply to use 0.3 or 0.7.

Question 7

Many candidates could do this question in their heads and scored full marks. For other candidates this question caused a number of problems.

(a) The majority of candidates began their response with either a Venn diagram or a probability tree; the simpler 2-way table was only seen occasionally. Nethertheless, many candidates were able to answer part (a) correctly.

(b) Candidates who recognized the reduced sample space of 50 students were able to produce very concise solutions although a significant proportion calculated the probability of the student wearing glasses given the student is studying Arts subjects rather than the probability of the student <u>not</u> wearing glasses given the student is studying Arts subjects. Others tried to multiply probabilities without any real consideration as to whether or not the events were independent.

(c) A large number of candidates identified the need to look at all three subjects in turn and then sum. There were however, some candidates that failed to take account of the different number of students studying each subject and just added the percentages and divided by 3. A minority of candidates believed that 0.8 x 0.75 x 0.7 was sufficient.

(d) Recognition of the need for conditional probability in part (d) was good. Some candidates however wanted to divide by probability of the student studying Science subjects rather than the probability of the student being right handed. Some did not see the connection between parts (c) and (d) and tried to calculate the probability of a student being right handed again and achieved a different result to (c). The numerator in the calculation was not always correctly calculated – some candidates did not look at the 80% from science and just used 30 out of 148 as the numerator.

Statistics Unit S2

Specification 6684

Introduction

This paper was shown to be accessible to the majority of candidates and there was no evidence of them being unable to complete the paper owing to time constraints. Many of the candidates seemed to be confident with the work they had learnt in statistics at A2 level. It was disappointing to see that some candidates did not relate some of their answers to the context of the question being posed. For example, in question 3, where candidates were asked to give conditions for the choice of a Poisson model, they should have given these conditions by relating the learned theory to the context posed in the question. Questions 1, 2, 3, 5, 6a, 6b, 7a and 7b were usually a good source of marks for a majority of the candidates. As with previous years, the question relating to the definition of statistical terms was again poorly answered. A noticeable number of candidates also struggled with questions 7c and 7d. Also, some were also unable to produce a clear, well drawn sketch of the continuous random variable in question 6.

Report on individual questions

Question 1

Most candidates attempted this question and achieved good marks. Part (a) was completed well. There were a large number of responses which relied on an informal, intuitive approach involving ratios. Part (b) was less well done and provided a variety of responses. A substantial minority of candidates had failed to read the question properly. They assumed that the "second random sample" had the same size as the first random sample. These candidates also assumed that the proportion of people with green eyes had somehow changed.
As a consequence common errors included using n = 125 or using p = 3/125. When np = 3 was used correctly then a common error was to calculate npq = 2.88 and leave this as a final answer.

Question 2

This question was generally completed to a high standard. Errors in part (a) included using ¼ x or not stating ranges. It is perhaps significant that those candidates who drew quick sketches were least likely to forget about the ranges. Part (b) caused few problems and most candidates were awarded the mark. Some candidates used integration, which was time-consuming for 1 mark. Part (c) was generally done well, errors included: division by 2, or adding a and b, or not squaring. There were again a small number of candidates who chose to integrate, using $Var(X) = E(X^2) - [E(X)]^2$, despite the fact that this involves considerably more work than the formula. However, many of these responses were accurate. There were a large number of perfect solutions to part (d). The relative simplicity of the function perhaps gave these candidates a chance to demonstrate their understanding of the topic. Many successful candidates were able to skirt the issue of a 'variable upper limit'. However, the most common, and serious, problem was the failure to deal with the lower limit of the definite integral. There is of course an alternative approach using an indefinite integral. A few candidates used this method successfully, clearly calculating and stating the constant of integration. There were many, however, who omitted the constant of integration. The B1 ft allowed some weaker candidates to score well in this part. Sometimes the ranges for 0 and 1 were confused. Part (e) was generally very well done by a large majority of candidates. There was evidence that candidates who had become confused and discouraged in the earlier parts had made a fresh start to part (e). The use of diagrams to identify the required area was again fairly common and appeared to help candidates.

Question 3

Many candidates did not achieve any marks in part (a) as they failed to give conditions in context, events being the most common error seen. Part (b) was done well and if candidates lost a mark then it was usually the final mark due to accuracy. A common answer was 0.082. Part (c) was generally completed satisfactorily, but there were a number of candidates who struggled with the inequalities. A common error was $P(Y > 7) = 1 - P(T \leq 6)$.
Diagrams were again in evidence; these candidates were perhaps the least likely to make mistakes with the inequalities. Some candidates calculated a probability using P(2.5) and then squared their answer. The overall response to part (d) was good. However, only a minority scored full marks. Most candidates failed to implement the instruction to write their answer "to 2 decimal places".
There were other errors; omission of the continuity correction or the wrong version (40.5), confusion between variance and standard deviation, and problems dealing with a negative z-value.

Question 4

This question proved difficult to many candidates. Errors in this part (a) included the use of the word sample rather than population. Many candidates also gave an ambiguous response to part (b), often omitting to mention all sampling units or the whole population.
Part (c) was done badly and whilst some candidates scored 1 mark very few achieved both marks. It appeared that many candidates had attempted to memorise the definition, but it came out garbled and confused with other concepts.

Question 5

The overall response was good, with a large number of candidates scoring at least five out of the seven marks. However, a small number of candidates chose to ignore the instructions to "use a suitable approximation". Most candidates were familiar with the conditions required for the Poisson approximation to the Binomial in part (a). However, a small number of candidates quoted this correct reason, but used this as justification for a Normal approximation. Not all candidates using the Poisson distribution earned the second mark. A final answer of 0.156 was fairly common, particularly amongst those who had used the Poisson formula rather than the cumulative tables.

The response to part (b) was excellent. There were a large number of perfect answers. A small number of candidates ignored the instruction to approximate and continued the use the Binomial distribution. Cumulative tables are not available for this particular distribution, so candidates calculated five separate probabilities using the Binomial formula and then added, resulting in many of them able to obtain the correct answer using this method.

Question 6

Most candidates responded well to this question. However, a smallish number were rather confused; integrating instead of differentiating, and *vice versa*, confusing mode and median and substituting $x = 0.5$ in $F(x)$ instead of solving $F(x) = 0.5$ in part (d). The majority of candidates provided satisfactory solutions to part (a) and earned all four marks, although a very small number attempted to 'fake' the proof. The most common error was the omission of "= 1". There were a large number of perfect solutions to part (b) with concise and accurate working. The overall response to part (c) was again satisfactory, although a sizeable minority used f(x) or integrated. In part (d) a majority of candidates established the quartic equation. However, this was as far as most of them went. A small proportion went on to solve the disguised quadratic, usually using 'the formula', although 'completing the square' was seen on a few occasions. A minority attempted numerical techniques to obtain an answer correct to three significant figures. All too many candidates produced this incorrect solution;

$$x^2(8 - x^2) = 8$$

$$x^2 = 8 \quad \textbf{or} \quad 8 - x^2 = 8$$

$$x = \sqrt{8} \quad \textbf{or} \quad x = 0$$

In part (e) the appropriate comparisons were generally made although this did not always lead to the correct conclusions being made. There were many correct answers, although if the evidence of the responses from parts (e) and part (f) were considered together, it could be construed that some candidates were guessing. The first mark in part (f) was mostly for administration; labels and the horizontal sections. The lines x<0 and x>2 were often omitted and labels were often incorrect. For the second mark, too many candidates drew small, inaccurate sketches that were symmetrical with the mode at x=1 rather than slight negative skew.

Question 7

This proved to be a difficult question but a lot of good mathematics was seen. In part (a) most candidates obtained both marks. Most candidates obtained the first mark in part (b), but the second proved elusive for some. A final answer of 0.146 was common. Part (b) was important for focusing the mind in part (c) on a Binomial distribution with *p>0.5*, i.e. not in the tables. However, there was still some confusion evident. A majority of candidates earned the first three marks. Most candidates who proceeded beyond this point decided to adopt the Bin (20, 0.25) approach. There were problems identifying the correct inequality with a common misconception was that the correct value was $P(X = 13)$ or $P(X = 7)$. Other less common errors were $P(X < 13)$ and $P(X \geq 13)$ or their counterparts. There were a substantial number of responses where candidates decided to use a Normal approximation and some candidates even used a Poisson distribution (Po(7.5)). Part (d) was fairly demanding, but there were candidates who provided answers that were not only correct but also clear and concise. The remainder struggled. Many candidates failed to distinguish between $X \sim B(20,0.75)$ and $Y \sim B(20,0.25)$, using *X* to denote both distributions. This caused confusion in the interpretation of their solutions, when candidates obtained a 'final' value of eleven. This was a *Y* value and needed conversion to an *X* value.

Statistics Unit S3

Specification 6685

Introduction

The paper proved to be very accessible to the candidates and there was no evidence that they were unable to complete it in the time allowed. Many of the answers were very well presented showing a high level of competence. There were some areas that still need to be improved. Examples are the definition of hypotheses, learning definitions and giving conclusions in context.

Report on individual questions

Question 1

Many candidates were unaware of the reasons for the use of stratified sampling but most could give one advantage and one disadvantage of quota sampling.

Question 2

There were many correct answers to this question but there were also some common errors. These were the use of the wrong standard error and being unable to handle a negative z-value.

Question 3

Many candidates produced completely correct solutions to this question. Ill-defined hypotheses, poor arithmetic and not giving the conclusion in context were the common errors.

Question 4

The scatter diagram was usually well drawn but the obvious curve in the data was rarely commented on in the final part. Few candidates knew what was measured by the product moment correlation coefficient. The numerical parts of the question and the significance test were well answered.

Question 5

Ill-defined hypotheses often resulted in lost marks at the start of the question and when calculating the degrees of freedom. Many candidates did not work sufficiently accurately when calculating the expected frequencies with consequent loss of marks but generally the question was well answered.

Question 6

Part (a) was usually well answered by most of the candidates. Many candidates did not really understand how to tackle part (b) and of those that did many did not interpret the phrase ‘lies within’ correctly.

Question 7

Many candidates did not read this question carefully and in part (a) used one cola can and one lemonade can rather than two cola cans as stated in the question. Part (b) was usually correct but in part (c) poor arithmetic and confusion of units caused many candidates to lose marks. The idea that all the random variables were independent was lost on most candidates.

Statistics Unit S3 Coursework

Specification 6685

The standard of the projects this year was very variable. There were many of a high standard and more than usual of a low standard. The better candidates continued to find new topics to investigate. Some centres had decided that all their students should do the same topic; where this happened they all seemed to make exactly the same mistakes and the projects seemed to be less successful. Most projects were neatly presented.

Candidates usually gave consideration as to how they were going to collect their data and how they could avoid bias, but many candidates then failed to give details of the data collected even in summary form. Occasionally the data could be found on a spreadsheet in the appendix.

Diagrammatic representation could have been better.
Scatter diagrams were seen with all the points clustered up one corner. Even if a computer is used to draw the diagram both scales do not have to start at zero. Many candidates were unable to differentiate between bar charts and histograms. This problem mainly occurred when diagrams were computer generated. It is likely that candidates were unable to alter the bar chart that is the standard offering on Excels chart drawing wizard.
Often diagrams were drawn after a test had been done. (These diagrams often negated the need for the test previously done). This usually went hand in hand with a failure to interpret a diagram.

There was more testing for a normal distribution model with μ known and σ^2 unknown this year, some even had the correct degrees of freedom ($\nu = n - 2$). There was the usual muddling of $\nu = n - 1$ and $\nu = n - 3$, the former often being used to avoid $\nu \le 0$ (caused by small sample size).
Once again this year we had both Spearman's rank coefficient and PMCC done on the same data – candidates are expected to choose the most appropriate.
All the old errors were still there this year – E's < 5 and/or combined wrongly particularly in contingency tables and often with degrees of freedom unadjusted; sample size too small for central limit theorem; central limit theorem stating the sample, rather than sample means, were normally distributed; non –frequencies for χ^2 etc.

There was a general failure to interpret diagrams but otherwise the interpretations and conclusions were done quite well.

Many teachers had again written comments on their candidate's projects and again moderators found this most helpful. As this is the last year of projects the moderators would like to thank all the teachers who have done this.

Thanks are due to all the teachers who have overseen their student's projects, marked and commented on them and made them such a high standard.

Statistics Unit S4

Specification 6686

Introduction

There was a small entry for this unit and most of the candidates that were entered were well prepared. Whilst most of the topics in the specification were generally understood, there were areas that caused problems for candidates. Examples were the use of the *F*-distribution tables, pooled variance and confusion of the Normal and *t*-distributions.

Presentation of their answers and the use of good notation were areas that need to be improved together with the giving of conclusions in context. This being said it was pleasing to see some very good scripts.

Report on individual questions

Question 1

Many candidates were able to answer this question correctly but too many showed that they had not understood the *F*-distribution tables. A clear shaded and labelled diagram would have helped many candidates.

Question 2

Although generally well answered common errors were the division of the standard deviations; confusing the degrees of freedom and hence finding the wrong critical value; not giving the conclusion in context and not making reference to the population in the final part.

Question 3

Many candidates gained full marks for this question. The usual reasons for not doing so were poor arithmetic and not giving the conclusion in context.

Question 4

The first three parts of this question were not well answered with many not knowing the conditions for the use of a paired *t*-test. Many could not relate to the practical aspects of this question. Apart from poor arithmetic part (d) was usually correct although the conclusion was not always in context. The correct diet was usually stated in part (e) but the reason was not always convincing.

Question 5

Most candidates were familiar with terms such as Type I error, size of test, power and Type II error and overall the question was surprisingly well answered. Only the final part was not well answered.

Question 6

Apart from those candidates that used the Normal distribution rather than the *t*-distribution part (a) was often correct. Surprisingly few candidates gained full marks in part(b). Common errors were poor arithmetic when calculating the pooled estimate of the variance; using the wrong *t*-value; using the wrong formula for the confidence interval by dividing the *t*-value by the standard error.

Question 7

Although the notation of some of the candidates could have been better the norm for this question was full marks. This aspect of the specification was well applied to this question.

Statistics Unit S5

Specification 6687

Introduction

The majority of the candidates for this paper had clearly prepared very well and it was pleasing to see many comprehensive solutions to the longer, more involved questions. There was little evidence of candidates running short of time. It was clear from the solutions offered that candidates were very competent in statistics, although some aspects of the paper proved very demanding for even the best candidates compared to previous years

Report on individual questions

Question 1

This question was generally very well answered with many candidates gaining full marks.

Question 2

The use of a Venn diagram to help identify probabilities was missed by a large number of candidates and many attempts using a tree diagram lost a number of marks in part (a). Many solutions understood what was required in part (b), but candidates often could not determine the numerator accurately.

Question 3

This question was a good source of marks for many candidates. Attempts were well presented and many solutions were clear and accurate.

Question 4

Candidates found this question demanding. Attempts at part (a) and part (b) often gained some credit for use of the Poisson distribution and an attempt at the definite integral, but few candidates realised that part (b) could be used for part (c) and the explanations in part (d) missed the point.

Question 5

Many candidates were unable to deal with simple fractions in this question and many lost marks in part (a) and part (b). As in question 4, very few candidates realised that part (c) could be used to give the answers to part (d) and (e) and spent a lot of time calculating irrelevant, complicated integrals involving the exponential function.

Question 6

Candidates often confused the distributions in this question, with the answer to part (c) often offered in part (b). The more complex probabilities later on in the question defeated many; although even some weak candidates were able identify the geometric progression in part (e) successfully.

Question 7

This long, involved question proved very demanding for many candidates. Many solutions started well, with most marks being gained for the probabilities in part (a). From part (b) onwards, many candidates did not consider carefully the requirements of the question and lost marks as a result. The best candidates were able to discuss the probability of acceptance at length, but missed the points relating to the proportion accepted by each scheme.

Statistics Unit S6

Specification 6688

Introduction

The paper proved to be accessible to the majority of students. Most candidates completed the paper within the time allowed and attempted the questions in the order set. Many more candidates completed the front cover of their scripts correctly by showing the number of the questions answered and the order in which they were answered. It is pleasing to see that the majority of candidates are now giving their final conclusions in the context of the question.

Report on individual questions

Question 1

Many candidates gained full marks on this question. A minority of candidates did not make their hypotheses clear. The notation m_1 and m_2 were often used in the hypotheses but were not defined.

Question 2

This question was popular amongst candidates with many of them gaining full marks.

Question 3

Many candidates recognized the need to use the normal approximation and correctly calculated the mean and the variance. The majority of students were then able to continue and gain full marks.

Question 4

This question was tackled well by all candidates. The main error seen was one of accuracy. Candidtaes used rounded figures rather than accurate ones in their calculations.

Question 5

The majority of candidates were able to tackle this question but few gained full marks. The main error was in part (b) where the incorrect z values 1.644 and 2.323 were commonly seen.

Question 6

This question was popular amongst candidates with many of them gaining full marks

Question 7

Parts (a) and (b) were generally well answered although a minority of candidates did not give their answer to the given degree of accuracy in part (a).
In part (c) many candidates stated that "the assumption is justified" but few gave a sensible reason as to why this was the case. In part (d) few students gained full marks. The majority of students were unable to state the assumption about ε_i and the explanations of how to use the residuals were poor.

Statistics Unit S6 Coursework

Specification 6688

Projects were generally of quite a high standard this year, although the number of entries was less.

Candidates continued to find new topics to investigate, many making interesting reading. Those centres where the whole class had attempted the same topic did not seem to do so well as those that gave their candidates a free choice.

Many candidates did not pay enough attention to data collection; this is an important part of any investigation, and deserves proper consideration. The full data was often not summarised within the main body of the report and a search of the appendix often showed that it was missing.

Again this year some candidates failed to represent the data diagrammatically, and many that did failed to interpret the diagram. One particular failing (also common to S3 projects) was to draw a bar chart when a histogram was appropriate and then to go on and call it a histogram

The actual analysis was in most cases done correctly, although in one or two cases the most appropriate test was not selected, particularly when the sample size was large and the data was from what could be considered to be a normal distribution.

With some centres the interpretation and conclusion drawn were rather weak; more is expected than a statement of the results of each test.

This is the last year of A level Statistics projects. Over the years projects have been kept at a very high standard. It is hoped that candidates have benefited from doing them and from seeing statistics in action. Perhaps it has also helped them to understand the various tests better and to be able to see through the many ways of lying with statistics.

Moderators have each year commented on how helpful they had found teachers comments on the projects. Thanks are due to the many teachers who have willingly cajoled their students into doing projects, marked and commented on them.

Decision Mathematics Unit D1

Specification 6689

Introduction

This paper proved to be accessible to the candidates, although there was some evidence of time being a problem for some candidates, there is still a need for centres to teach efficient ways of presenting the working. The standard of presentation was very variable and in some cases this made the solutions very difficult to follow.

Good answers were usually seen to question 6(c), and often seen to questions 2(a), 2(b), 3(a), 3(b) and 5. Poor answers were often seen to 2(c), 7(a), 7(d) and 7(e).

Report on individual questions

Question 1

The vast majority of candidates showed that they understood the concept of quick sort, with very few bubble sorts seen. Most candidates chose to start with one of the 54's as a pivot and a number of candidates were unsure what to do with the second 54. Some chose 2 pivots initially, or created an incorrect order where the two 54s were next to each other. However, most candidates dealt well with this situation. Other common errors were: not identifying a pivot towards the end of the quick sort, where two numbers were already in the correct order, fragmenting the list rather than selecting pivots concurrently and the regularly seen re-ordering of the sub-lists. Many candidates did not produce a list of **students** in order.

Question 2

Most students were able to find a Hamiltonian cycle, though some omitted the end point and some did not start at A as requested. Most candidates were then able to draw the cycle as a hexagon and went on to answer this part well. A surprisingly large number of candidates did not make any connection between the Hamiltonian cycle and the planar graph and tried to draw the graph without first drawing the cycle as a boundary between the two sets of arcs. The explanation seen in part (c) was not done well with invalid crossings given and crossing arcs not named. Many didn't realise that EF could often be added without any crossings. Most considered the crossings inside for AF but not outside.

Question 3

The first two parts of this question were well answered with most candidates identifying the three pairings and their weights. Many forgot the units when stating the length of the minimum route and some wasted time by listing their route. Only the better candidates were able to answer part (c) correctly – some tried to exclude the longest arc in the pairings rather than seeking to include the shortest and some only considered the two arcs used in their initial shortest route. Some correctly identified CD as the arc they should repeat and some stated that they should start and finish at A and F, but only the best gave both parts for a complete answer.

Question 4

This question produced a good range of marks. Most candidates were able to score some marks in part (a) with very few activity on node responses seen. Common errors were: omitting arrows- which is particularly serious on the dummy arcs, adding superfluous dummies - often around D, having multiple start and end points, and omitting the final (MN) dummy. The first dummy was usually correctly drawn and usually well explained in part (b). The uniqueness constraint leading to the second dummy seemed to be less well understood. Some candidates gave a general comment about dummies rather than the specific explanation needed. (On a different note many candidates referred to 'a dummie' rather than 'a dummy' in their explanation).

Question 5

This was a good source of marks for most candidates, with most being able to find at least one correct alternating path between E and 5. Some candidates however split a correct path into 2 loosing both M marks. Many did not offer a second alternating path and a few started or finished their alternating paths at already matched vertices. A number of candidates forgot to make clear the 'change status' step of the algorithm. Most made their two final matchings clear. There were many correct alternative answers to part (b) but most used the argument shown in the mark scheme. The explanation was not always well done with a lot of incomplete or confused explanations.

Question 6

Candidates had to apply Dijkstra's algorithm very carefully to obtain full marks in part (a) and many were able to do this. There are still a few candidates who treat this as a sort of 'minimising critical path' forward pass however. The examiners use the working values and the order in which they occur in the box as the main confirmation that Dijkstra's algorithm has been correctly applied, thus it is important that they are legible and that candidates do write them in order. The order of the working values at E, G, I and H were often incorrect, and the working values at E, G and H were often incorrect. Most candidates were able to find the correct route and length. Those that gave a numerical demonstration in part (b) gained full marks most easily, but those who gave a general explanation often missed out part of the process. Many candidates were able to score full marks in part (c).

Question 7

This was surprisingly poorly done by a large number of candidates. Very few candidates mentioned the context here with many giving stock phrases such as 'they make the inequalities into equalities' or that they are 'slack variables'. Most candidates were able to select the correct pivot although the 4 in column Z was a popular incorrect choice. A number forgot to change the basic variable in the new pivot row and there were the usual arithmetic slips. Most alarming was the number of candidates who, having made errors, seemed quite happy to have negative numbers in the value column. The values should never be negative (due to the non-negativity constraints) and this always indicates that some error has been made. Very few candidates listed a full set of the variables in part (c), with r or P being frequently omitted. Part (d) was poorly done with double equal signs, P or 9100 omitted and for those who did get the right 'ingredients' signs muddled up, of those who did get the correct equation almost none were able to go on to use it to answer part (e), most gave the standard response that there were negatives in the profit row of the tableau. Part (f) was usually well done, and mostly candidates answered this by circling the next pivot on their tableau in part (b); however surprisingly many candidates chose a negative pivot.

Question 8

Most candidates dealt with the supersource and supersink correctly and added the correct numbers on the edges, but many omitted the arrows in part (a) and made arithmetic slips in part (b). Most candidates were able to increase the flow to 109 correctly, but a large number of candidates tried to use routes involving a flow from C to B. Candidates should not list the routes that give the initial flow as part of their new augmented flow route list, but should give the value of the flow they send along each route they use. Part (d) was often poorly done with many sending flow from C to B as the commonest error. Of those who found the correct maximum flow only a very few obtained the correct minimum cut and linked the two with the max-flow min-cut theorem. Most candidates were able to make some progress with part (f) but very few gave complete answers.

Decision Mathematics Unit D2

Specification 6690

Introduction

The paper proved to be accessible to the majority of candidates, with most candidates being able to make a good attempt at all the questions.
Questions 1, 2 and 5 were well-answered by the vast majority of candidates. Those questions requiring a written sentence response (questions 4(a) and 6(a)) were often poorly answered, as were those requiring the formulation as a linear programming question, with question 6 (d) being particularly poorly handled, having said that some very good answers were frequently seen to question 3.

Report on individual questions

Question 1

Most candidates answered this very well, with only minor errors being made. These minor errors included numerical slips in calculating shadow costs and improvement indices, using two empty cells in a stepping stone route, nit indicating the stepping stone route, including an extra zero in the improved solution and choosing an incorrect theta value.

Question 2

This was well-answered by most candidates. A number of candidates made errors in finding the lower bound, including AB in their RST or using nearest neighbour. Many candidates did not draw the correct conclusion about the better lower bound. Most candidates completed part (b) correctly. In finding the upper bound some candidates did not return form G to F but doubled their route from F to G. Others included the direct route from A to D (27) rather than the least route (26) giving an upper bound of 139km.

Question 3

Some very good and some very poor answers were seen to this question. Some candidates did not define their decision variables, or changed notation mid-way through the question. Notation generally was sometimes weak. Many candidates were able to list the objective function correctly, but the constraints were often poorly handled with multiplication of variables by costs a surprisingly common sight.

Question 4

Many candidates did not present a good definition of a maximin route and were not able to offer a good practical example. Part (b) was often well-answered although some candidates found the minimax or minimum or maximum route instead. Other common slips were a few numerical errors, failure to indicate the optimal choice at each state and swapping the order of the states, making it impossible to follow the route back though the table.

Question 5

This was a rich source of marks for most candidates. Only a very few minimised. The most common errors were arithmetical slips in part (a). The units caused some problems in part (b) with candidates often writing down an answer that was a multiple of 10 out.

Question 6

Many candidates did not give a correct definition, with ‘sums of gains and losses equal zero’ instead of ‘sums of gains equal zero’ being popular. Part (b) was well-handled this time by most candidates. Most candidates were able to set up three equations but graphs were sometimes very poorly drawn, with common errors being lack of ruler, no scale, incorrect lines drawn and the domain extending beyond 1 or below zero. Most candidates were able to select the correct point but the other two points were both frequently chosen by candidates. The strategy or value was omitted by some. Many poor responses to part (d) were seen, many candidates did not define the probabilities or adapt the matrix to B’s perspective. Candidates frequently made errors in their constraints.

Very many candidates did not answer the question asked in part (c) and did not draw the matrix from his perspective but instead attempted to solve the game for Freddie, wasting time and gaining no marks.

Grade Boundaries

June 2005 GCE Mathematics Examinations

The table below gives the lowest raw marks for the award of the stated uniform marks (UMS).

Subject Number	Grade Boundaries				
	80	**70**	**60**	**50**	**40**
6663	60	52	44	36	29
6664	60	52	44	36	28
6665	61	53	46	39	32
6666	52	45	38	32	26
6671	60	52	45	38	31
6672	61	53	45	38	31
6673	58	50	43	36	29
6674/6667	59	51	43	35	28
6675/6668	52	45	38	32	26
6676/6669	52	45	38	32	26
6677	63	54	46	38	30
6678	60	53	46	40	34
6679	54	47	40	33	27
6680	55	48	41	34	28
6681	57	50	43	36	29
6682	55	48	41	34	27
6683	53	46	39	32	25
6684	61	54	48	42	36
6685*	82	72	63	54	45
6686	60	53	46	39	32
6687	57	50	43	37	31
6688*	82	72	62	52	42
6689	47	40	34	28	22
6690	65	58	51	44	38
6691	60	53	47	41	35
6692	60	53	46	39	32

*6685/6688 marks are out of **100**, all other marks are out of **75**.

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