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25th June 2012

Mela Watts
Director of Free Schools Group
Department for Education
Sanctuary Buildings
Great Smith Street
London SW1P 3BT

Dear Ms Watts,

Thank you for your letter of March 13 2012. We would like to express King's College London's formal interest in opening a specialist mathematics school, with the objectives, ethos and organisational structure described below. The first full cohort of pupils would enter in September 2014. We summarise our plans following the structure of your letter to us. This summary reflects more detailed discussion, planning and underlying documentation, which we look forward to sharing with you if our proposal goes forward.

In this letter we provide first an overview of our vision for the school; second, responses to each of your questions; third, our proposal for the immediate next steps towards opening a school; and, fourth, appendices providing more detail on particular content and castings.

I. King's College London Specialist Mathematics School

We propose to develop a school which will help to increase substantially the national pool of high attaining, well educated and trained young mathematicians, and which will recruit intensively among talented young people who currently do not have access to high quality sixth form mathematics provision. We are confident, on the basis of our current outreach work to schools, that such a pool of talent exists in London and its surrounding areas.

In responding to your invitation, our academic staff and senior management team have sought to identify the core contributions that we might make as a university. These centre on the development and delivery of the mathematics curriculum; outreach to schools, to supplement and improve current Key Stage 4 mathematics teaching and provide for a qualified entry cohort; and a research programme associated with the school which would identify and develop good practice in teaching gifted young mathematicians. This is where we propose to concentrate our efforts, while collaborating with an established academy chain, management group or other external agency who would provide administrative expertise and services for the day-to-day running of the school.

The London context

We are conscious, from direct experience, of the challenges posed by the current state of mathematics teaching in the schools which potential pupils attend. It is a situation which reflects the acute shortage of good mathematics teachers in this country, and it is why young people from lower socio-economic groups are even more heavily underrepresented in STEM subjects than in higher education as a whole. Our planning for the school has, as it must, taken account of the mathematics education that our target pupils currently receive.

Potential students, across London, are likely to have experienced a mathematics curriculum that is bereft of creativity, excitement and challenge. We see the capacity to tackle the STEP examination by the end of year 13 as an obvious and important end point for pupils at our and indeed any specialist mathematics school. However, the gap between the mathematics in the current GCSE - even at A* grade - and the STEP examination is very large indeed, and the challenge is compounded rather than offset by the nature of the teaching that many pupils receive. We consider this gap to be too large to be overcome in just two years for most students, even those with very high potential, and even with the very best academic teaching during their sixth form years.

For this reason, we are convinced that the school can only achieve its objectives, and those of government policy, if we operate an outreach programme in London schools for promising students in years 10 and 11 (i.e. the GCSE years). Moreover, if we are to enrol the first full cohort of students in 2014, we need to start the outreach programme immediately. The programme would be an essential component in bridging the gap between the current mathematics curriculum and the academic mathematics curriculum offered in a specialist school and beyond. Through the outreach programme, students will engage in mathematics: it will allow them to experience and tackle difficult, non-routine and extended problems.

I will return to the required outreach activities in more detail at the end of this letter. The plan for the school outlined in the next section should, however, be read with the understanding that it assumes prior activity with a high proportion of entering students, to enable them to follow a demanding curriculum and progress to high levels during their time at the school.

II. Structure and Operation of the School

In this section, I respond, in order, to the requests for information made in your letter.

1. Key features of the school: its ethos, aspirations for the achievement of pupils and the role the university will play in running the school.

Ethos The school will provide its students with an academic sixth-form curriculum which strongly emphasises mathematics. The aim will be to create an intellectual climate in which talented and motivated students will thrive, developing powerful mathematical understanding and a deep appreciation of the nature of mathematics. Any examinations taken will be hurdles which the student takes in her/his stride when the time comes rather than high-jumps whose anticipation colours the entire programme. The atmosphere will foster uninhibited study and discussion of ideas for their own sake. Balancing this pursuit of pure knowledge, the school will also provide encounters with modem applications of mathematics and with wider cultural and social issues. (See section 2 and Appendix I.)

Governance Detailed governance structure will need further discussion but we would assume that a standard Trust-based structure will be appropriate. We suggest the following for discussion, which adds a King's based curriculum management committee to the normal academy structure:

a. A *Trust* consisting of

- the sponsor, King's College London (KCL)- as an entity, rather than a named individual
- individuals appointed by KCL - including at least one staff member from Mathematics and one from Education
- the Chair of Governors

The Secretary of State might have the right to appoint a member.

b *Directors* (perhaps known as governors, with the board of directors known as the governing body) with responsibility for overseeing the operation of the school. Membership to include:

members of KCL staff
community governors appointed by KCL (including individuals with a background in mathematics, science and engineering)
The School Principal (in an ex officio capacity)
parent and school staff representatives
Representatives of 'feeder' institutions, including academy chains and federations

The Secretary of State may also have the right to appoint directors.

c. King's College London *Curriculum Management Committee* to work with the school's head teacher and other relevant staff to develop the strategic vision, especially with reference to the mathematics curriculum.

2. The curriculum the school will follow (including the proportion of time spent teaching each subject), qualification which might be offered, the approach to teaching and learning and how these will help develop mathematical thinking and prepare students to study maths (and related degrees) at top universities.

Although there is much dissatisfaction in the mathematics community about A-level, the actual mathematical content of A-level is not the main cause of this. The difficulty lies in the routine and uninteresting way in which the material is largely taught and assessed. Therefore, there is a need to develop both the school curriculum and how it is taught: something to which King's College London can contribute through its exceptional mathematics and education faculty.

The curriculum needs to cover the material in A-level mathematics and further mathematics. Our aim would not be to cover all of this rapidly and then start on university first year material, but rather to teach mathematics which includes, but is not confined to, the A-level material in a way which develops mathematical thinking and an understanding of the logical connections within the subject. Students should be able to do much more than answer problems of a standard kind using standard techniques. The working group has developed some quite detailed thinking on the specific curriculum implied by this approach. A summary is provided in **Appendix I.**

The mathematics curriculum, and how it is taught, lie at the heart of the entire initiative, and there can be no compromise on its quality if the initiative is to succeed. Particular features of a King's College Specialist Mathematics school would be:

- much greater mathematical rigour which supports the general supposition that statements are proved and methods justified
- an emphasis on oral discussion, argument and collaboration. This is not common in English mathematics teaching, historically or today, but is very important in many other teaching traditions (including Russian, German, French.)
- putting work in mathematical and historical context
- applications informed by current use of mathematics
- integration of methods and ideas used in computer science

Existing assessments (A levels, STEP, possibly Pre-U) can be used to provide external certification. Our planning is based on the expectation that the cohort take STEP papers. We would hope and expect, in collaboration with other specialist mathematics schools, to be fully

engaged in any redevelopments of the mathematics A-level which arise from recent governmental and Ofqual announcements concerning increased university engagement with A-levels and also with other work on post-16 mathematics and curricula sponsored by DfE and/or being carried out under the aegis of ACME (Advisory Council on Mathematics Education).

All students would study physics (and most would take physics A level) as well as some computer programming. In addition, while students would not be encouraged or pushed to accumulate large numbers of examination passes, they would continue with a broad general curriculum, including other sciences, philosophy, other social sciences and humanities; foreign languages; and have opportunities for sports and arts. Some of these subjects, notably foreign languages and sports, could be delivered through existing King's facilities.

We will investigate how best to offer chemistry (and biology), including making arrangements for any students who change direction after their first year, and need A level chemistry for their chosen university courses. Our proposed collaboration with an academy chain or consortium should provide appropriate facilities and teaching for any such pupils, and means that we will not need to develop expensive and underused facilities in subjects which are not central to the school's curriculum.

Teaching will be partly in classes of 30, and partly in smaller groups of 10 or 15. Independent study will include small-group work involving pupils, or pupils plus a university post graduate student. The layout of the school needs to provide for small study rooms which are now standard in most university libraries and which can be used for group work. We envisage the library, with study rooms, as one of the two focal points of the school, along with the shared social space (see below). We would enable access to King's library facilities for the school staff and pupils.

It is envisaged that there will be close involvement by King's faculty with the appointment and development of school staff, including mentoring, CPD and joint development of research and scholarship. This connection, we believe, will help to attract high calibre teachers to the school and ensure excellence and innovation in educational practices and outcomes. (See also section 7 below.)

3. Planned yearly intake and how pupils will be organised

We propose an entry of 60 pupils a year, with the first full intake in 2014-15 (with a head teacher appointed from Spring 2013). All will follow a 2 year programme, in their year group. In line with our practice for undergraduates, all pupils will have a personal tutor from among the school permanent staff. The tutor will be the first point of contact on personal and career issues (including university applications), supported by King's and other universities, as appropriate.

We also propose to assign each pupil to a small mathematics tutor group. Each group will be associated with a King's College PhD student, Post Doctoral Fellow or Teaching Fellow, who will act as a 'mathematics mentor' for the pupils in their group.

4. School timetable and calendar and plans for extended hours

At this stage, our detailed timetabling remains provisional, but we have worked on the basis of 40 timetabled hours a week (contact + independent and group study), almost half of which is devoted to mathematics, and a 35 week school year, which is probably a maximum. **Appendix** I summarises our current thinking on time allocation as well as subject spread, and provides some detail on the mathematics to be covered.

We expect that the school will remain open each day well beyond the end of the timetabled lessons, to allow pupils to use the library, work in groups, etc. We also expect that the school will be used on Saturdays for outreach activities. Pupils and staff will be invited and encouraged to attend seminars and lectures at King's on a regular and appropriate basis.

5. Admissions policy and plans for identifying and selecting pupils

Students will be selected on merit according to the following criteria:

- demonstrated mathematical potential
- potential for success in the specialist setting
- appropriate university course/career aspirations in mathematics or a related discipline (including statistics, physics, chemistry, biological sciences, economics, computing but not courses such as medicine)

As noted above, our intention is to recruit a very significant number of students from groups who would not otherwise have access to high quality mathematics provision, and increase the total pool of high-achieving young mathematicians and applicants for maths, and also physics, engineering and related degrees. We would monitor our admissions carefully in order to ensure that we achieve this aim, widen the number and type of schools feeding pupils into top-quality Mathematical and Physical Sciences degrees, and in so doing also increase the socio-economic diversity of these faculties.

Selection of pupils must be fair and effective in identifying talent, and must be seen as such. Especially in the early years of the schools, this is likely to be a time-consuming and expensive process and we are strongly of the opinion that development work should take place in collaboration with other proposed mathematics schools. We have spent a considerable amount of time considering how selection should take place, in discussion with academic experts outside as well as inside King's who have extensive experience in identifying pupils with high levels of talent in particular areas.

In the lead-up to the school's opening, we propose to develop and refine a selection policy built around and integrated with outreach activities for promising students in years 10 and 11 (i.e. the GCSE years). As noted above, the outreach programme would be an essential component in bridging the gap between current school provision and the mathematics school's curriculum and will allow students to gain experience in tackling difficult, non-routine and extended problems.

Our intention is that the outreach programme would have a wide and 'inclusive' reach. We would work with local schools and academy chains to identify a relatively large pool of students with potential who do not currently have access to sixth form mathematics provision of the highest academic quality. Students would be selected at the beginning of year 9 for the outreach programme using a relatively 'low key' and inexpensive examination such as the UKMT or a non-verbal reasoning test; and considerably more students would be included in the programme at this point than will enter the school. Final selection for the school would then be through a bespoke academic entrance examination that is rigorous, reliable and valid, and reflects curriculum demands and the nature of mathematical thinking.

This entrance examination will be relatively expensive to develop, but can be administered securely, and used over a good number of years. We would hope and propose to develop it in collaboration with other universities and schools in the initiative in order to spread these costs.

6. Type of premises and resources needed and thoughts on possible locations

The site of the proposed specialist school is vital to its success. To ensure that our vision is realised, it is important that it be located close to the Strand Campus of the College (where the Department of Mathematics is located) and the Waterloo Campus (where the Education Department is located, on the other side of Waterloo Bridge).

The relationship between the School and the University will be partly determined by curriculum and governance; but unless it is close to King's the concept of a 'university school' will be very difficult to develop and make a reality. It will only be practicable for King's staff and students to be involved on-site in a regular way if the premises are close by. (See section 7, below: staffing structure.) It will help school staff and students to benefit from seminars, lectures and broader university based activities if they can get to and from the school easily. Close proximity will make it feasible for pupils and school staff to make use of university facilities such as the modem language centre and libraries.

Because of its proximity to Waterloo (main station and Waterloo East), King's College is very easily accessible to a wide swathe of south London, including areas of considerable social deprivation, as well as to the Kent and Surrey suburbs and beyond. A school close to Waterloo can thus draw on a very large catchment area, in which there will be large numbers of prospective high-attaining students. The school should be within a maximum 15 minute journey time from Waterloo Bridge if it is to be genuinely accessible to this whole catchment area. The College's current estate is fully utilised, and we have no spare capacity, so the school will require newly acquired high quality premises.

We have completed a preliminary detailed assessment of site requirements, based on Department for Education guidelines and recommendations. We have had a preliminary discussion with the Department for Education on this, and are keen to develop our ideas further. Our initial estimate was that a site to accommodate 120 pupils required a little over 1000m^2 and the EF A has been able to confirm that we are within the standard area allocation for a facility of this size.[1]

In reaching this estimate, we have worked on the assumption that the school will remain small (120 fulltime pupils) but also that it should be suited and used intensively for outreach activities out of hours, including Saturdays and school holidays. We propose to have only one laboratory, for physics, on the premises. We assume wireless broadband throughout, and that computer programming can be done in a regular classroom using laptops. AS noted earlier, some non-core subjects will be offered elsewhere, rather than catered for on-site. (See Appendix I.)

This approach requires a number of conventional classrooms, with a flexible layout, and two large spaces which are central to our curriculum approach. The school should have a sizeable library, incorporating a number of small rooms for group work, and a number of computers with large displays, and using a combination of flexible, formal and informal learning spaces as are nowadays commonly found in modernized university libraries. At the core of the school, there should be a large common space which can be used for lectures and presentations (especially during outreach sessions) but which is also, most of the time, a social space, for discussion, meetings, and informal learning. We would incorporate a small cafe. If the school is a new-build, we would like the design to bring staff and pupils through this space on a regular basis throughout the day (emulating the design of the Isaac Newton Institute at Cambridge).

7. *Proposed staffing structure including involvement of university staff or students*

[1] [redacted] of the EFA has created an appropriate schedule of accommodation to deliver the intended provision and provided us with a working figure, including partitions, corridors etc, of 1150 m^2.

The staffing model needs to support the School's vision of mathematical excellence, and combine stability, through fulltime, dedicated teaching staff, with building direct links into the King's Mathematics and Education Departments through individuals who are formally attached to both the Departments and the School. Students will attend lectures, and receive them from visiting academics: but the staffing model also needs to create structural links with the university.

We propose to establish links between the Mathematics Department and the school faculty in a number of ways. First, we believe that we can attract high quality full time mathematics teaching staff to the school, partly because of the quality of the student body, but also by offering them regular access to King's mathematics seminars, lectures, etc, and an ongoing close relationship with College. Second, we are developing a model for combining teaching at the school with part-time mathematics PhD study at King's. Third, we propose to use students as tutors and mentors to the pupils. Fourth, we would like to discuss with other mathematics schools making a joint approach to the Research Councils about ways of improving current UK provision for post-docs in mathematics and mathematics education and the possibilities for linking these into the schools initiative. In addition we will offer all school staff (and not just the mathematics staff) opportunities for close contact and links with our Department of Education and Professional Studies. We think that a good number are likely to be interested in postgraduate study, including PhDs, in regular attendance at seminars and lectures, and in other forms of CPD. The Department's Centre for Research in Education in Science, Technology, Engineering and Mathematics (CRESTEM)[2], which includes the Mathematics Education Research Group, provides a focal point for such links.

8. Likely capital and revenue costs and details of how financial plans will support the vision for the school

We distinguish between short-term and start-up costs, and longer-term revenue requirements. We are clear that building up the school will be considerably more expensive, on an annual basis, than its long-term revenue needs, because of the current shortfalls in school mathematics teaching, and because this is an entirely new initiative. As already noted, in some areas, including admissions, we think that collaboration among all mathematics schools is important and will significantly reduce costs and increase effectiveness. As also noted, a new site is required as the College does not have premises available.

The school would be administered as a stand-alone unit. King's College London's strengths are in the development of mathematics curriculum and mathematics education, and the efforts and time of university staff will be concentrated on this. We therefore propose a partnership, probably with a successful academy chain, to set up the school and manage its day-to-day running.

It is increasingly clear that chains (and federations) are providing an efficient administrative model for schools. We have not had any formal discussions about this, although the College has pre-existing and good relations with potential partners; or with any other provider of management services. Our costing is therefore done in advance of any input from them. We have, however, developed an initial detailed staffing model as a basis for costing.

We estimate that the per pupil cost for programme delivery once the school is fully enrolled will be circa £5000, based on class sizes that vary between 15 and 30 throughout the school year, and the curriculum outlined in Appendix I. This cost includes teaching payroll and administration, management and facilities payroll costs. Costs are based on School Teachers Review Body pay-scales and King's College London pay-scales and are also

[2] King's coordinates the ESRC's Targeted Initiative in Science and Mathematics Education, and two of its five projects are carried out by CRESTEM staff

consistent with salaries offered at other high achieving state and non-state funded local institutions (e.g .Highgate School and London Academy of Excellence). Please note that many of our pupils will come from deprived areas and are likely to be eligible, under current government arrangements, for additional per-pupil funding.

Our vision for the school (see above and section 8 below) includes a major ongoing role for outreach into London schools, and for research which will feed into teaching nation-wide. These components need to be treated separately for funding purposes and are not included in the per-pupil estimate given above. Because of the urgency of starting outreach, we have provided some costings for the first phase (Appendix II). We would also wish to incorporate arrangements for funding longer-term outreach, admissions test development, and research, into a formal contract with DfE.

8. How the school might share learning and resources with nearby school and colleges and more widely

Outreach is central to our vision and plan for the school, not only as a way of selecting pupils, and ensuring that they are ready to engage with the curriculum, but also as a way of improving mathematics education beyond the group who actually attend the school.

Maintaining close links and good working relationships with local schools will be vital to the success of this initiative. Local schools would play a crucial role in identifying talented young mathematicians and it is important that they perceive the school as a benefit not a threat. The outreach programme will, from the start, provide mathematics enrichment for all those who attend rather than just those who eventually enter the school, and can incorporate informal CPD for their teachers and schools as a whole.

In the longer term, we intend to seek independent funding for a larger CPD programme associated with the school's curriculum and pedagogy (see Appendix II), and to offer it to a wide range of schools and students, using school premises out of hours. This will contribute directly to schools' teaching quality (and results), and is an important direct benefit that we can offer in return for schools' collaboration in identifying potential students. Once the school is established and well known, it will draw from a large number of feeder schools, none of which is likely to send more than two or three pupils a year. We are nonetheless aware of the potential for some schools, notably those with broad sixth forms, to be unhappy at losing some of their highest attaining students. Hence, we would like to explore with DfE whether and how the originating schools could continue to include students in their results for reporting and accountability purposes, thus providing an incentive to work with the King's school.

We envisage that the mathematics school's teachers will develop and evaluate new and exciting approaches to teaching mathematics, in conjunction with university mathematicians and mathematics educationalists. At present, there is little to no research on effective maths education for high-achieving secondary pupils. We will now have the opportunity to research the efficacy of approaches and disseminate findings; and will also build them into a wider programme of CPD for which we will seek funding outside the mathematics school programme itself.

We see a research element as critical if this and other mathematics schools are to realise their potential as an influence on mathematics teaching nationally. A long-term research relationship between the school and King's College London mathematics education academics is built into our vision and planning. We envisage that these initiatives would in time lead to improved A-level teaching across the London area in particular, and that the school will influence the mathematics curriculum and mathematics teaching for high attaining

students more generally, to the wider benefit of the school community in London and nationally.

III Next Steps

We, like you, are very conscious of time pressures if a school is to open, with a full first year entry, in September 2014. We have prepared a timetable which assumes a head teacher in place by Spring 2013; but also underscores the need to begin some activities this September 2012. We would therefore like to propose

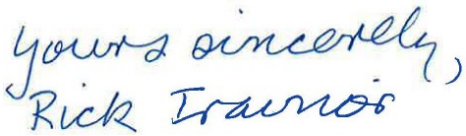
- an initial contract between DfE and ourselves to cover immediate work on outreach, and to run from September 2012 for six months. This would allow us to start work with potential pupils who are currently at KS4, create awareness of the maths school initiative among schools, pupils and parents, and also address any possible barriers to schools' helping suitable pupils to prepare for entry. The nature and costs of this proposal are detailed in Appendix II. As explained there, the College's existing work on widening participation will allow us, with some additional funding from DfE, to achieve critical mass and move quickly to establish outreach. As emphasised above, we are convinced that this is a necessary precondition for a successful London mathematics school which aims to recruits the most promising and motivated young mathematicians from schools where they are currently ill-served.

- continuing dialogue and discussion between ourselves and DfE with a view to confirming school governance arrangements, clarifying the nature of outsourced administrative activities, advancing the location of premises, and establishing, in collaboration with other planned mathematics schools, the nature and development process for formal admissions procedures.

- negotiations should be completed by the end of 2012, with a view to our entering into a firm contract to establish a school on the basis of these discussions, and taking into account experiences with the outreach pilot. This contract would follow on from the preliminary outreach contract, (Sept 2012- Feb 2013) and allow the appointment of a head-teacher. It would also incorporate additional outreach activities, and development of admissions procedures, leading up to the school's opening in September 2014, and specify procedures/ arrangements for funded research on curriculum and pedagogy from the time the school opens. (See Appendix III.)

- following refinement of the plans and preparation of a draft contractual agreement, we can take the proposal to establish a King's College London Specialist Mathematics School to College Council for formal discussion. Council has been informed of our interest in the initiative, and we will keep them informed of progress in advance of requesting their necessary and formal decision on the matter.

Professor Leinonen and I look forward to discussing these proposals with the Secretary of State on July 2nd. If you would like further clarification of any points before that meeting, please let me know, copying your request to Professor Leinonen and the other members of the working group who were in receipt of your March letter.



cc Dominic Cummings
REDACTED
Attachments: Appendices I, II, III

Appendix 1: timetable and curriculum

As stated in our main response, the aim would not be to cover A-level mathematics and further mathematics rapidly and then start on university first year material, but rather to teach mathematics which includes, but is not confined to, the A-level material in considerably more depth. Our aim would be to teach mathematics in a way which develops mathematical thinking and an understanding of the logical connections within the subject and would give students an insight into how mathematicians think and work in academia and beyond. Students would be required to do much more than answer routine problems of a standard kind using standard techniques. Particular features would be:

- much greater mathematical rigour and the general supposition that statements are proved and methods justified
- an emphasis on oral discussion, argument and collaboration
- putting work in mathematical and historical context
- applications informed by current use of mathematics
- integration of methods and ideas used in computer science
- university-led tutorials and seminars
- opportunities to audit first year undergraduate courses

We envisage that students would take the STEP (and possibly Pre-U). Students would also take existing A-levels in mathematics, although our intention is that they would find these examinations straightforward. Additionally we aim to develop innovatory and challenging alternative academic mathematics qualifications, possibly in collaboration with other schools in this initiative. Whilst these would initially be designed for this group of able students, our intention is that these could, and would, be used more widely in UK mathematics teaching.

All students would spend almost half their time on mathematics, partly in lessons, partly in university-led seminars and partly individually or with other students. All students would also study physics (and most would take physics A-level) and include some computer programming in their timetable. In addition, while students would not be encouraged or pushed to accumulate large numbers of examination passes, they would continue with a broad general curriculum, including other sciences, philosophy and other social sciences/humanities, foreign languages.

Provisional timetable: 22 hours direct contact time, 20 hours timetabled independent study and small group work

	Contact	P and I
Mathematics	9	8.5
Physics	4**	3**
Chemistry and Biology	2	1.5
Computer Programming	1.5	1.5
Foreign Language	1.5	1.5
Humanities and Social Science (including some of history, philosophy, English literature, economics, geography, politics)	2**	2**
Arts (at least one of music, theatre, visual arts)	0.5	1
Sport (not necessarily team sport)	1	
Community service	0.5	1

*Times are averages; for mathematics this would be a steady rate, but in some subjects there might be wide variations from week to week. Private study hours are indicative, suggesting a lower limit of expectation rather than timed sessions, although for some of the

P and I mathematics time more informal teaching support would be available, partly in university-led ad hoc seminars.

** In Y13, there would be possible virement from mathematics and physics to computer programming or social science for those intending to study computer science, economics and possibly statistics at university.

We have developed a (provisional) 'meta-syllabus' for 16-18 maths teaching, listing some key mathematical ideas which ideally a teacher will bear in mind, to give a sense of mathematical travel as individual topics are taught. There are many aspects of mathematics, such as mathematical reasoning, which are not taught per se but should develop as specific mathematical topics are engaged with. Students should be helped to understand these goals as their mathematical maturity increases. [Alongside each .idea, in square brackets specific topics are given which exemplify how students might be drawn towards these goals. These are mostly beyond the A-level syllabus, but approachable with guidance by students in this age range.]

1. The underlying logical nature of mathematics: axioms, definitions, theorems, proofs [2 dimensional Euclidean geometry]
2. Limits and convergence [geometric series, Newton-Raphson method and simple fixed-point theorems]
3. Exactness and approximation, order of error terms [Derivative defined in multiplied-up form as $f(x + h)= f(x) + hf'(x) + h\eta(h)$, $\eta(h) \to 0$ as $h \to 0$, Taylor's theorem with remainder]
4. Leibnitz rule [applied to a variety of products, eg scalar and vector products]
5. What integrals do for you [centre of mass, expectation]
6. What analysis can do for you [using properties of absolutely convergent series (to be assumed rather than proved) to define exponential function, sine, cosine via their series expansion and establish their properties]
7. Algebraic reasoning with products which are not commutative [matrices to solve linear equations, combining rotations about different centres by expressing a rotation as a combination of two reflections]
8. Linear spaces [Linear dependence, bases, linear transformations]
9. Changing to a coordinate system adapted to the problem in hand [conics and general equation of second degree]
10. Mathematical models [systems which exhibit approximate simple harmonic motion]
11. Eigenvectors and eigenvalues [conics again, stability, electron spin, Markov chains,]
12. Stability and its absence [SHM again, less intuitive dynamical systems]
13. Classification [isometries of the plane, conics again]
14. Equivalence classes [two-dimensional projective geometry, periodic functions as functions on the circle]
15. Algebraic structures in various contexts [transformation groups, Boolean algebra]
16. Quantification of risk

Appendix II: Outreach Activities

As discussed above, we are clear that, without sustained outreach activities to feeder schools, it will be impossible to select a cohort of entrants who are fully prepared to tackle the school curriculum; and extremely difficult to identify accurately those with the relevant aptitude. If the school is to open fully in September 2014, outreach activity will need to start in autumn 2012.

In the medium to longer term, we propose to seek funding for outreach from a variety of sources. Our widening participation plans for 2013-14 have already been submitted to OFFA, but beyond that, we would wish to embed outreach and wider CPD associated with the specialist mathematics school into the College's widening participation activities. We also propose to make an approach to the Education Endowment Foundation as soon as formal agreement with DfE has been reached, and are also already discussing support for mathematics outreach with a number of other possible charitable donors.

We would also highlight our current "King's Factor" mathematics activity with sixth forms, which will enable us to accelerate outreach to younger pupils. The King's Factor programme is part of the College's formal widening participation programme for the next two years, and means that we have already established contacts with many of the schools most likely to be involved in Key Stage 4 outreach. We would propose to run the two elements together, thus providing matching administrative funds for the KS4 outreach from the College's own widening participation activity from the very start.

By March 2013 we hope to have signed a contract with DfE and also obtained supplementary funding in order to continue and expand the programme, to include admissions test development as well as larger student numbers. Admissions procedures would then start in 2013-14 for 2014 entry.

The budget below is based on a model of Saturday all day classes, which individual students will attend on a fortnightly basis. Classes will run every Saturday in term time from mid-September 2012 through March 2013, with senior teachers working with teaching assistants recruited from King's College mathematics students. The proposed funding would allow for about 200 students to attend classes. The staff costs are based on College pay grades for the part time co-coordinator and estimated daily (£200) and hourly rates (£18 for teaching and £14 for marking) for bought-in senior teachers and teaching assistants respectively.

Normally on grants of this type, the College charges overheads based on the number of full time equivalent staff working on the project: these would total £10,000 for estates costs and £40,000 other costs per FTE. However, since the Maths outreach days will take place at the schools and space costs are unlikely to be recharged to us we have excluded the normal estates related overhead. We also are aware of procurement constraints on the Department; and in order to enable rapid agreement and start for the project we have, for this occasion, reduced our overheads to £9880/12%.

Cost analysis for maths outreach	Sep12 £k	Oct 12 £k	Nov 12 £k	Dec 12 £k	Jan 13 £k	Feb 13 £k	Total £k
Salaries							
part time co-ordinator 0.4	2,359	2,359	2,359	2,359	2,359	2,359	14,152
senior teachers	1,800	1,800	1,800	1,800	1,800	1,800	10,800
teaching assistants	9,027	9,027	9,027	9,027	9,027	9,027	54,162

administrative support	667	667	667	667	667	667	4000
Pay Costs	**13,852**	**13,852**	**13,852**	**13,852**	**13,852**	**13,852**	**83,114**
Non-Pay							
Travel & materials	333	333	333	333	333	333	2,000
Total Direct costs	14,186	14,186	14,186	14,186	14,186	14,186	85,114
College overheads @ 25K per fte	3,980	3,980	3,980	3,980	3,980	3,980	23,880
less: discount	(2,333)	(2,333)	(2,333)	(2,333)	(2,333)	(2,333)	(14000)
Net costs	15,832	15,832	15,832	15,832	15,832	15,832	94,994

Appendix III: Associated Research

As discussed with you at the preliminary meeting between King's College and DfE staff, we believe it is critically important to build a research element into our activities. These should begin as the school opens and will increase its impact on mathematics teaching and wider curriculum development nation-wide. We propose two major activities, both to start in September 2014.

A. We will research the school's innovatory approaches to teaching mathematics. This will enable wider dissemination of innovatory teaching approaches and strengthen the evidence base of what works in mathematics education. Whilst this research element would ensure a positive influence on mathematics teaching more generally, the costs are relatively modest- a day per week of staff time together with a "rolling" PhD studentship.

B. We also propose to research the efficacy of this initiative (i.e. of all12 mathematics schools) by tracking students into their forties and beyond and comparing their outcomes to equivalent students not in the initiative. There is surprisingly little good empirical evidence on the impact of high mathematics attainment on later careers; and what exists relates largely to young people born in 19 58. The mathematics schools initiative offers a unique opportunity to correct this situation.