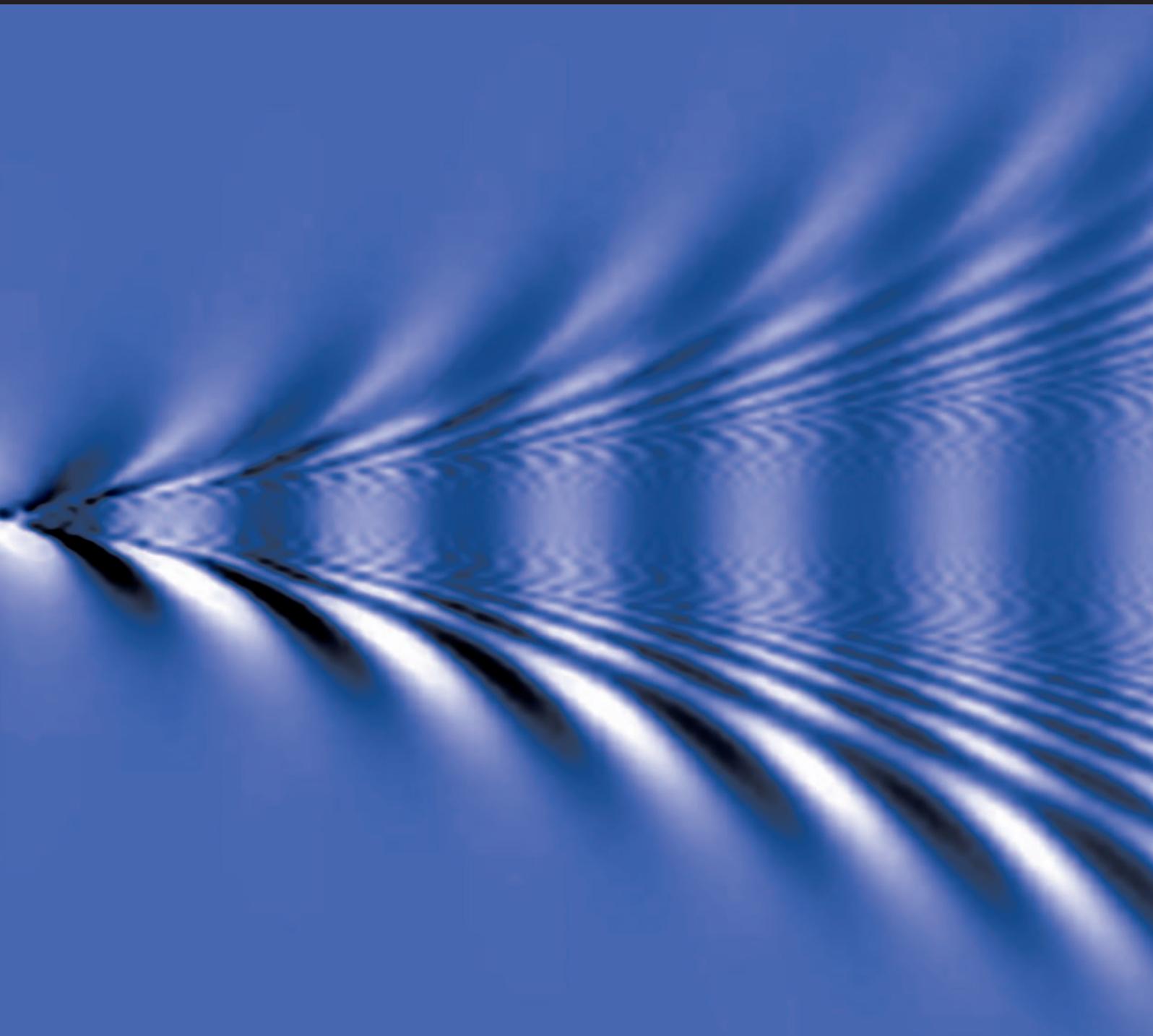


An Institute of Physics report | **July 2011**

Mind the Gap

Mathematics and the transition from A-levels to physics and engineering degrees

Appendix to the report prepared for the Institute of Physics by EdComs – full methodology and questionnaires



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1: Methodology

	Primary
Physics	1 x director of teaching and learning
	1 x head of second year
	1 x head of department
Engineering	1 x first-year tutor
	1 x head of first year
	1 x head of year

Full methodology

1.1. Stage one: qualitative telephone interviews with academics

Six 45-minute one-on-one telephone interviews were conducted with academics from three Russell Group universities (one physics academic and one engineering academic from each university).

These interviews were conducted between 14–24 February 2011.

1.1.1. Qualitative academic sample

The Institute of Physics and the Engineering Professors' Council provided contacts from physics and engineering departments at three Russell Group universities. The academics interviewed were not only actively teaching on physics or engineering courses, but also had some degree of student liaison role.

1.2. Stage two: quantitative survey with physics and engineering students

A total of 393 first- and second-year students, from the same three Russell Group universities, were surveyed through a 10-minute online questionnaire. They were contacted via the contacts provided by the Institute of Physics (an e-mail, drafted by EdComs and the Institute of Physics and containing a link to the survey, was forwarded to students from an academic at their university). The survey ran 28 February – 11 March 2011. A copy of the questionnaire can be found in section 2.

1.2.1. Quantitative sample

Table 2 shows the sample of students by their course type and year of study.

Table 3 shows the breakdown of qualifications

	First year	Second year	Total	Total by department	
Physics	53	66	119	180	
Astrophysics/particle physics and cosmology/theoretical physics/nanoscale physics/chemical physics	17	11	28		
Mathematics and physics	9	4	13		
Physics joint honours	2	1	3		
Physics "with" programme	10	7	17		
Aerospace engineering	15	5	20		183
Civil engineering	23	11	34		
Chemical engineering	15	6	21		
Mechanical engineering	26	19	45		
Electrical/electronic engineering	27	15	42		
Metallurgy and materials/engineering design/engineering mathematics/mechanical and materials engineering/mechatronic engineering	17	4	21		
Computer science	13	9	22	30	
Computer science and electronics/mathematics and computer science	3	5	8		
Total number of students	230	163	393		

	Physics	Engineering	Computer science	Total
Bachelors*	41	41	11	93
Integrated masters	139	142	19	300
Total	180	183	30	393

*Note that a number of the students that were currently studying towards a bachelors degree who were interviewed during the case-study visits indicated that they were considering switching to the integrated masters course. Some had not achieved the necessary grades to apply directly to that course, and so had enrolled on the bachelors course with a view to changing.

that the students surveyed were currently studying towards.

Table 4 shows the type of secondary school/college that the students had attended for sixth form.

1.3. Stage three: case-study visits with physics and engineering students

Qualitative face-to-face interviews were then con-

	Physics	Engineering	Computer science	Total
Comprehensive	65	46	7	118
Grammar	30	31	7	68
Sixth-form college	51	44	5	100
Independent/private	26	51	8	85
Further education college	6	9	1	16
Overseas/international	2	2	2	6
Total	180	183	30	393

ducted with 24 first- and second-year physics and engineering students from the same three universities that had taken part in the previous phases of the research. Respondents to the online survey had been asked to indicate whether they would be happy to take part in a further phase of research, and those who consented were re-contacted using the contact details that they had supplied. Respondents to be included in this phase were selected in order to provide a mix of degree course, year of study, whether they had taken further mathematics at A- or AS-level, and gender. Many had not decided whether to pursue a bachelors or integrated masters qualification, so that information has not been noted in this sample breakdown.

An EdComs moderator visited each university to conduct student interviews. It was necessary to fit in with student timetables, so interviews ranged from being one-on-one to being conducted in a focus group setting. As a result, the interviews ranged from 30 to 60 minutes in length, depending on the number of students being interviewed.

These interviews took place 23–29 March 2011.

1.3.1. Qualitative physics/engineering student sample

Table 5 shows the breakdown of the physics and engineering students interviewed during case-study visits.

1.4. Stage three: case-study visits with mathematics students

During the three case-study visits, nine first-year mathematics students from the same universities were also interviewed in relation to the secondary objective of the research. These students were chosen to have had the relevant qualifications to study physics at university (mathematics and physics A-level), and were recruited to take part via academics at those universities.

	First year	Second year	Total
Physics	3	5	8
Electrical engineering	3	1	4
Civil engineering	4	1	5
Aeronautical engineering	2	0	2
Mechanical engineering	3	1	4
Chemical engineering	0	1	1
Total	15	9	24

	Bachelors*	Integrated masters	Total
Mathematics	5	0	5
Mathematics and physics	2	1	3
Mathematics and computer science	1	0	1
Total	8	1	9

*Note that a number of the students that were currently studying towards a bachelors degree who were interviewed during the case-study visits indicated that they were considering switching to the integrated masters course. Some had not achieved the necessary grades to apply directly to that course, and so had enrolled on the bachelors course with a view to changing.

1.4.1. Qualitative mathematics student sample

Table 6 shows the breakdown of the mathematics students interviewed qualitatively.

1.5. Stage four: academic survey

Finally, a 10-minute online quantitative survey was conducted with 40 academics (34 physics academics; six engineering academics) from physics and engineering departments in 33 UK universities. A link was sent to a contact at each department by the Institute of Physics/Engineering Professors' Council. A copy of the questionnaire can be found on p11. This survey ran 4 March – 12 April 2011.

1.5.1. Quantitative academic sample

Table 7 shows the breakdown of the roles of the academics surveyed.

1.6. Analysis and reporting

Qualitative data was gathered into a thematic template to ensure coherence across the research team,

and was further evaluated during internal analysis sessions.

Quantitative student data was analysed across the following criteria:

- Degree course
- Year of study
- Whether further mathematics was studied
- Mathematics module studied (mechanics vs statistics)
- Grade achieved at A-level mathematics
- Whether additional support was taken up
- Type of secondary school attended

Only significant differences at a 95% confidence level have been commented on. Due to the small sample size, academic quantitative data was analysed only at an overall level. Direct quotes taken from qualitative interviews have been specified as [physics academic] or [engineering academic]. Quotes taken from open-ended questions asked in

Table 7: Academic sample

	Sample
Head/director of teaching	13
Lecturer/senior lecturer	11
Head of school/department	7
Course co-ordinator	4
Module/course leader	3
Tutor	2
Total	40

the online academic survey cannot be attributed to individual respondents and as such are labelled only as [academic].

The sample is not representative of the student or academic population as a whole but was designed to provide an effective indication of their attitudes.

2: Student questionnaire

Institute of Physics online student questionnaire

The Institute of Physics, in conjunction with the Engineering Professors' Council, have commissioned EdComs, an independent research agency, to conduct some research into students' perception of the mathematical content of undergraduate physics and engineering courses. The survey should take no more than 10 minutes of your time and there will be a prize draw at the end for a chance for you to win one of 20 prizes of £20.

Your responses will remain confidential, and all findings will be amalgamated and reported at a global level.

Firstly, we would like to ask you a couple of questions, to check that you are eligible to take part.

S1 What type of secondary school/college did you attend for sixth form? [select one only]

- Comprehensive
- Grammar
- Sixth-form college
- Independent
- Further education college
- Other (please specify)

S2 Which of the following subjects did you study at A/AS-level? [select all that apply]

- A-level maths (pure and mechanics)
- AS-level maths (pure and mechanics)
- A-level maths (pure and statistics)
- AS-level maths (pure and statistics)
- A-level physics
- AS-level physics
- A-level further maths
- AS-level further maths
- I did not study A/AS-levels (thank and close)

S3 What grade did you achieve in [select one per row]

	A*	A	B	C	D	E	U
A-level maths [ask if maths (pure and mechanics) at S2]							
A-level maths [ask if maths (pure and statistics) at S2]							
AS-level maths [ask if AS maths (pure and statistics) at S2]							
AS-level maths [ask if AS maths (pure and mechanics) at S2]							
A-level physics							
AS-level physics							
A-level further maths							
AS-level further maths							

S4 Which university do you attend? [select one only]

- University of Manchester (continue)
- University of Birmingham (continue)
- University of Bristol (continue)
- Other (thank and close)

S5 What course are you studying? [select one only]

- Physics
- Astrophysics
- Particle physics and cosmology
- Theoretical physics
- Nanoscale physics
- Chemical physics
- Maths and physics (joint honours)
- Other physics joint honours programme
- Physics “with” programme (e.g. physics with philosophy)
- Aerospace engineering
- Civil engineering
- Chemical engineering
- Mechanical engineering
- Electrical/electronic engineering
- Metallurgy and materials
- Other (please specify)
- Course not related to physics or engineering (thank and close)

S6 What qualification are you currently studying towards?

- Bachelors (e.g. BSc, BEng)
- Masters (e.g. MPhys, MSci, MEng)
- Neither (thank and close)

S7 Which academic year are you in? [select one only]

- First (continue)
- Second (continue)
- Third (thank and close)
- Fourth (thank and close)
- Other (thank and close)

If screened out

Unfortunately you are not eligible to take part in this study, but thank you for your time.

If eligible

We'd now like to ask you some more detailed questions about your course.

Q1 Why did you choose to study (insert course selected at S5)? [select all that apply]

- I need this qualification for the career that I intend to pursue
- I enjoyed maths at A-/AS-level and wanted to study a subject that would allow me to pursue this
- I enjoyed physics at A-/AS-level and wanted to study a subject that would allow me to pursue this
- Other (please specify)
- Don't know/not sure

Q2 To what extent were your expectations of your course met or not met? Why? Please provide as much detail as possible in the box below

Q3 Thinking about the mathematical aspects of your degree course, to what extent has the content of the course so far met or not met your expectations? [select one only]

- There is a great deal more mathematical content than I expected
- There is somewhat more mathematical content than I expected
- The degree of mathematical content meets my expectations
- There is somewhat less mathematical content than I expected
- There is a great deal less mathematical content than I expected

Q4 Compared to your expectations, how easy or difficult have you found the mathematical content of your degree course? [select one only]

- It is a great deal easier than I expected
- It is somewhat easier than I expected
- It is at the level that I expected
- It is somewhat more difficult than I expected
- It is a great deal more difficult than I expected

Q5a Have you found any of the following elements of the mathematical content of your course particularly easy? [select all that apply]

- Calculus
- Differentiation
- Integration
- Algebra
- Matrices
- Logs
- Exponentials
- Geometry
- Vectors and scalars
- Complex numbers
- Transposing equations
- Being able to identify the appropriate equations/techniques to solve problems
- Other (please specify)
- None

Q5b Have you found any of the following elements of the mathematical content of your course particularly challenging? [select all that apply] (apart from “other” and “none” cannot select same option(s) as selected at Q5a)

- Calculus
- Differentiation
- Integration
- Algebra
- Matrices
- Logs
- Exponentials
- Geometry
- Vectors and scalars
- Complex numbers
- Transposing equations
- Being able to identify the appropriate equations/techniques to solve problems
- Other (please specify)
- None

Q5c (asked to those who have selected any options other than “none” at Q5b)
What have you found challenging about these topics? Why? Please provide as much detail as possible in the box below

Q6 **How would you rate your ability to deal with the mathematical content of your degree course when you started the course?** [select one only]

- Very well
- Quite well
- Not very well
- Not at all well

Q7a **Has your university offered any support to help you to deal with the mathematical content of your degree?** [select one only]

- Yes
- No
- Don't know

Q7b (all who answer yes at Q7a)
What form of support has been available to you? [select all that apply]

- Extra tutorials
- Extra lectures
- Extra independent reading
- Extra question sheets to practise problem solving
- Links to external websites for practice questions
- Other (please specify)
- Don't know

Q7c (all who answer yes at Q7a)
Have you taken advantage of this additional support to help with the mathematical content of your degree? [select one only]

- Yes
- No

Q7d (all who answer no at Q7c)

You mentioned that you have not taken advantage of the support provided. Why is that?

[select all that apply]

- Not needed – I didn't have a problem
- Not in a suitable format
- Not available when I needed it
- I didn't have time
- I didn't realise the support was available
- Other (please specify)
- Don't know

Q7e (all who answer yes at Q7c)

What form of support has been MOST useful to you? (include only those responses selected at Q7b) [select one only]

- Extra tutorials
- Extra lectures
- Extra independent reading
- Extra question sheets to practise problem solving
- Links to external websites for practice questions
- Other (please specify)
- Don't know

Q7f (all who answer yes at Q7c)

Do you feel that this additional support sufficiently addressed the issue(s)? [select one only]

- Yes
- No

Q7g **What do you feel could have been done to help you to deal with the mathematical content of your degree, either before you started the course or in your first year of study? Please provide as much detail as possible in the box below**

Q8 **Have you taken any independent measures to help with the mathematical content of your degree?** [select all that apply]

- Yes – further independent study
- Yes – additional practice questions
- Yes – sought assistance from other students
- Yes – sought assistance from my tutor
- Yes – other (please specify)
- No

Q9a (ask to those who selected codes 1–9 at S5 – physics)

And finally, what career path do you intend to follow? [select one only]

- Further study – in the field of physics
- Further study – not related to physics
- Work in a physics-related job
- I intend to pursue a career unrelated to my field of study
- Other (please specify)
- Don't know

Q9b (ask to those who selected codes 10–15 at S5 – engineering)

And finally, what career path do you intend to follow after graduation? [select one only]

- Further study – in the field of engineering
- Further study – not related to engineering
- Work in an engineering-related job
- I intend to pursue a career unrelated to my field of study
- Other (please specify)
- Don't know/not sure

Many thanks for taking the time to complete this survey. Your feedback is of great value to the Institute of Physics.

- For taking part in this survey, you have the chance to enter a prize draw to win one of 20 prizes of £20
- We are conducting a further round of research that involves a short group discussion that will take place at your university. You would receive £20 for your participation.

If you are interested in the prize draw or taking part in further research, please provide your name, e-mail address and telephone number below and tick the box(es) as appropriate, otherwise please leave blank. We will not use your details for any other purpose than to contact you for the reasons stated. Please note that providing your details does not guarantee that we will contact you unless your name is drawn in the prize draw.

Name

E-mail

Tel

- Please enter me for the prize draw to win £20
- I would be happy to be contacted in relation to further research related to this survey

Thank you very much.

3: Academics questionnaire

Institute of Physics online academics questionnaire

The Institute of Physics, in conjunction with the Engineering Professors' Council, have commissioned EdComs, an independent research agency, to conduct research into academics' perceptions of students' preparedness for the mathematical content of physics and engineering degrees. You have been asked to complete this survey on behalf of your department, so please consult with your colleagues where appropriate. The survey should take no more than 10 minutes of your time and your participation would be greatly appreciated.

Your responses will remain confidential, and all findings will be amalgamated and reported at a global level.

Firstly, we would like to ask you a couple of questions about your role.

Q1 Which university do you work at? [select one only]

- | | |
|---|--|
| <input type="checkbox"/> University of Bath | <input type="checkbox"/> University College London |
| <input type="checkbox"/> University of Birmingham | <input type="checkbox"/> Loughborough University |
| <input type="checkbox"/> University of Bristol | <input type="checkbox"/> University of Manchester |
| <input type="checkbox"/> University of Cambridge | <input type="checkbox"/> University of Newcastle upon Tyne |
| <input type="checkbox"/> University of Durham | <input type="checkbox"/> Nottingham Trent University |
| <input type="checkbox"/> University of Exeter | <input type="checkbox"/> The Open University |
| <input type="checkbox"/> University of Hertfordshire | <input type="checkbox"/> University of Oxford |
| <input type="checkbox"/> The University of Hull | <input type="checkbox"/> University of Salford |
| <input type="checkbox"/> Keele University | <input type="checkbox"/> University of Sheffield |
| <input type="checkbox"/> University of Kent at Canterbury | <input type="checkbox"/> University of Southampton |
| <input type="checkbox"/> University of Central Lancashire | <input type="checkbox"/> University of Surrey |
| <input type="checkbox"/> Lancaster University | <input type="checkbox"/> University of Sussex |
| <input type="checkbox"/> University of Leeds | <input type="checkbox"/> University of Warwick |
| <input type="checkbox"/> University of Leicester | <input type="checkbox"/> University of York |
| <input type="checkbox"/> University of Liverpool | <input type="checkbox"/> University of Nottingham |
| <input type="checkbox"/> Liverpool John Moores University | <input type="checkbox"/> Aberystwyth University |
| <input type="checkbox"/> Imperial College London | <input type="checkbox"/> Cardiff University |
| <input type="checkbox"/> King's College London | <input type="checkbox"/> Swansea University |
| <input type="checkbox"/> Queen Mary, University of London | <input type="checkbox"/> The Queen's University of Belfast |
| <input type="checkbox"/> Royal Holloway, University of London | |

Q2 What department/school do you work in? [select one only]

- Physics (and astronomy)
- Mechanical engineering
- Chemical engineering
- Civil engineering
- Electrical/electronic engineering
- Aeronautical engineering
- Engineering mathematics
- Mathematics
- Other (please specify)

Q3 And what role do you have in the department/school? Please provide details in the box below. If you are completing this survey in conjunction with other colleagues, please write in the roles of all involved

We would now like to ask you about your undergraduate students and their ability to cope with the mathematical content of their degree course. For the purposes of this survey we would like you to think about your first-year students.

The word fluency is used several times in the questions below. By this we are referring to students' levels of comfort with algebraic and arithmetical manipulation, and not needing to use a calculator for basic calculations.

Q4 Thinking of first-year undergraduates joining your course, how would you rate, on average, their ability to deal with the mathematical content of the course? [select one only]

- They are very well prepared
- They are quite well prepared
- They are not very well prepared
- They are not at all well prepared

Q5 To what extent do you agree, or disagree, with the idea that students joining your course lack fluency in maths? [select one only]

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q6 (only those selecting first two options at Q5)
What proportion of your first-year students would you say lack a degree of fluency in maths?
Please write in a whole number between 0 and 100 in the box below

			%
--	--	--	---

Q7a **Do you assess your incoming students' mathematical ability in their first year?**

- Yes
- No
- Don't know

Q7b (only those selecting yes at Q7a)
How do you do this?

- Diagnostic test at the beginning of the year
- On-going tests throughout the year
- Monitoring coursework marks
- Other (please specify)

Q8a **Which of the following, if any, elements of degree-level mathematical content do your first-year students particularly struggle with?** [select all that apply]

- Calculus
- Differentiation
- Integration
- Algebra
- Matrices
- Logs
- Exponentials
- Geometry
- Vectors and scalars
- Complex numbers
- Transposing equations
- Being able to identify the appropriate equations/techniques to solve problems
- Other (please specify)
- None

Q8b Which of the following, if any, elements of degree-level mathematical content do your first-year students find particularly easy? [select all that apply]

- Calculus
- Differentiation
- Integration
- Algebra
- Matrices
- Logs
- Exponentials
- Geometry
- Vectors and scalars
- Complex numbers
- Transposing equations
- Being able to identify the appropriate equations/techniques to solve problems
- Other (please specify)
- None

Q9a Does your department/school offer any additional support to help first-year students deal with the mathematical content of their degree? [select one only]

- Yes
- No
- Don't know

Q9b (only those selecting yes at Q9a)

What form of support does your department/school offer? [select all that apply]

- Extra tutorials
- Extra lectures
- Extra independent reading
- Extra question sheets to practise problem solving
- Links to external websites for practice questions
- Other (please specify)
- Don't know

Q9c (only those selecting yes at Q9a)

How long has your department been offering this additional support? [select one only]

- Just this academic year (a year or less)
- 1 – less than 3 years
- 3 – less than 6 years
- 6 – less than 10 years
- 10 years or more
- Don't know

Q9d (all who answer yes at Q9a)

Do you feel that this additional support sufficiently addresses the issue(s)? [select one only]

- Yes
- No

Q9e **What else do you feel could be done to help first-year students to deal with the mathematical content of their degree, either before they start the course or during their first year of study? Please provide as much detail as possible in the box below**

Q10 **Have you had to adapt the overall structure and/or content of the core physics/engineering degree course in light of incoming students' mathematical ability?**

- Yes
- No

Q11a **To what extent do you agree, or disagree with the idea that first-year students' lack of fluency in maths is an obstacle to them achieving their potential in the long term** [select one only]

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q11b **To what extent do you agree, or disagree with the idea that first-year students' lack of fluency in maths affects the departments' ability to deliver an optimal programme of study** [select one only]

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q11c (only those selecting options one or two at Q11b)

Could you please provide some more detail on how you feel the optimal programme of study has been/may be affected?

Many thanks for taking the time to complete this survey. Your feedback is of great value to the Institute of Physics and the Engineering Professors' Council.

Mind the Gap

Mathematics and the transition from A-levels to physics and engineering degrees

Appendix to the report prepared for the Institute of Physics by EdComs – full methodology and questionnaires

For further information or a copy of the full report please contact:

Sophie Robinson

IOP Institute of Physics

76 Portland Place

London W1B 1NT

Tel +44 (0)20 7470 4800

Fax +44 (0)20 7470 4848

E-mail sophie.robinson@iop.org

www.iop.org

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