University of BRISTOL

150 years young

150 Years and Counting



Professor Oliver Johnson

Head of School of Maths

linktr.ee/bristoliver

01

The root of it all

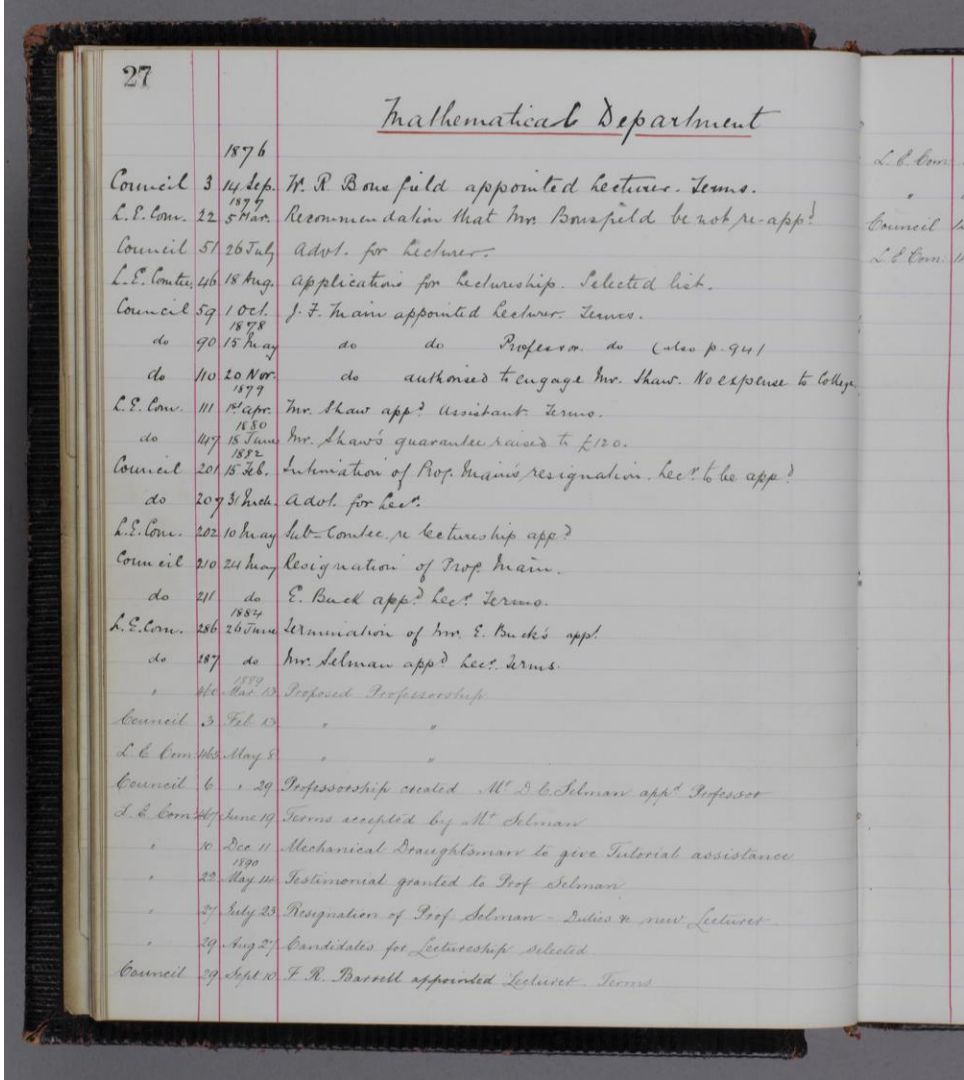
10th October 1876 – an inauspicious start [K61]

On Tuesday morning [*10th*] the College opened, Mr Bousfield giving a quiet ordinary mathematical lecture at 9 a.m. We had not a grand inaugural field day – the Council, in spite of our gentle suggestions, not seeing their way to this. However, the opening address by Professor Rowley (on Modern History) was understood to be *the* opening, and at 11 o'clock the largest of our lecture rooms was *packed*.

- Silvanus Thompson: letter to his father

First few lecturers [DM506-12]

- William Robert Bousfield (1854-1943) had graduated from Cambridge that summer.
- By March 1877 "*recommendation .. be not re-appointed*".
- Became KC, MP and FRS.
- 1877 John Frederic Main appointed - soon promoted to Professor of Mathematics, Applied Mechanics and Engineering.
- 1879 "*Mr Shaw assistant*" – Henry Hele-Shaw, left 1884, later Royal Institution Christmas lecturer.
- 1882 Main left, E. Buck appointed.

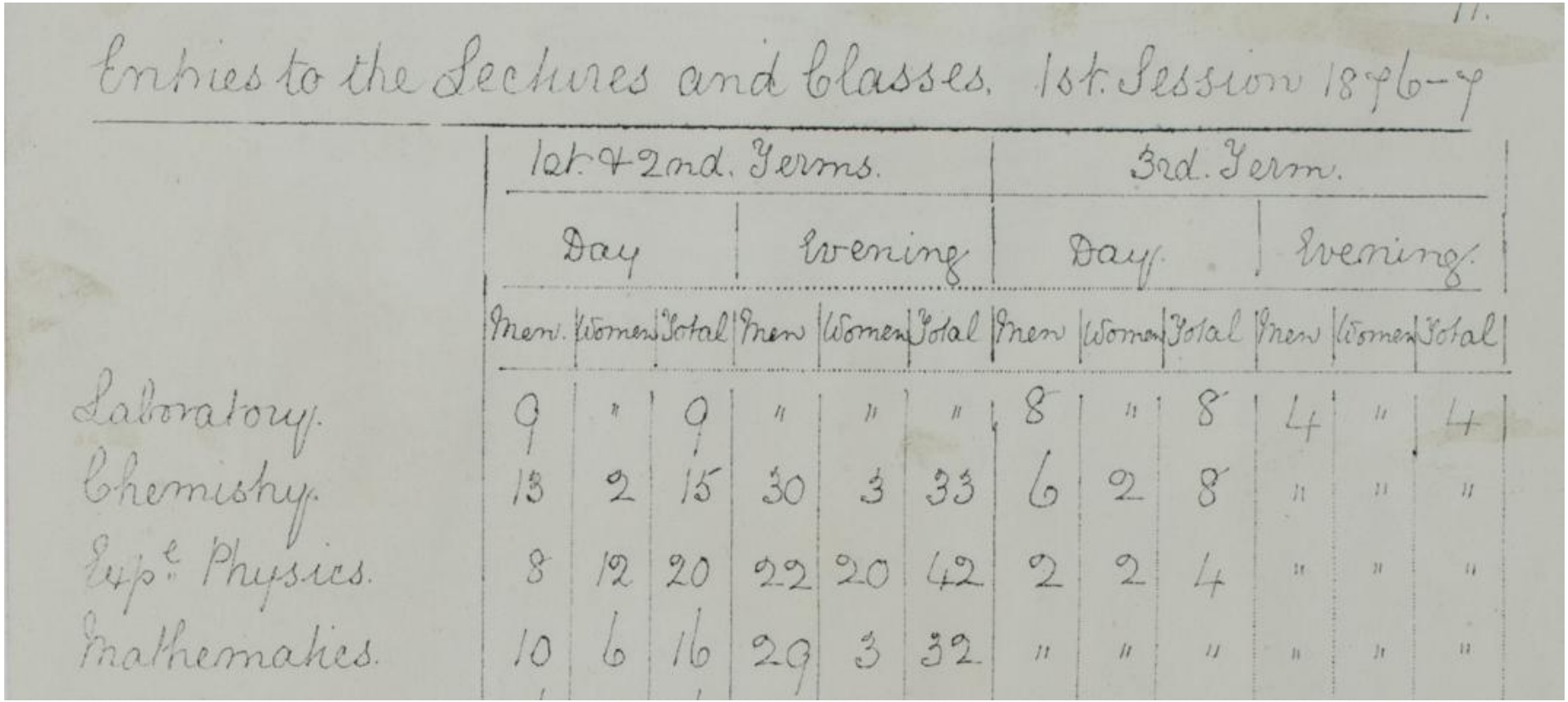


Nature 10th July 1884

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

UNIVERSITY COLLEGE, BRISTOL.—A correspondent writes:—This session has been most successful, the numbers of students in attendance being considerably larger than in the two preceding years. Funds are wanted more seriously than ever to complete the building and provide additional accommodation. Nothing has yet been done towards an endowment fund. Mr. E. Buck, M.A., Lecturer in Mathematics, has resigned his position on the staff. The Demonstrator in Physics, Mr. Colman C. Starling, has also resigned his post in consequence of internal rearrangements. The Chair of Geology and Physiology, left vacant by the resignation of Prof. Sollas, has been filled by the appointment of Mr. Lloyd Morgan.

Female students present from the start [DM-506-57]



Entries to the Lectures and Classes. 1st. Session 1876-7

	1st. & 2nd. Terms.						3rd. Term.					
	Day			Evening			Day			Evening		
	Men.	Women	Total	Men	Women	Total	Men	Women	Total	Men	Women	Total
Laboratory.	9	"	9	"	"	"	8	"	8	4	"	4
Chemistry.	13	2	15	30	3	33	6	2	8	"	"	"
Exp.l Physics.	8	12	20	22	20	42	2	2	4	"	"	"
Mathematics.	10	6	16	29	3	32	"	"	"	"	"	"

Even know some of their names … [K58]

That twelve students had presented themselves for examination for the general scholarships namely seven ladies and five men, and three students for examination for the Chemical scholarship.

That from the latter they had selected as Chemical scholar:

John E. Baker, Cumberland Road.

With a recommendation to attend lecture in English.

From the former they had selected as general scholars:

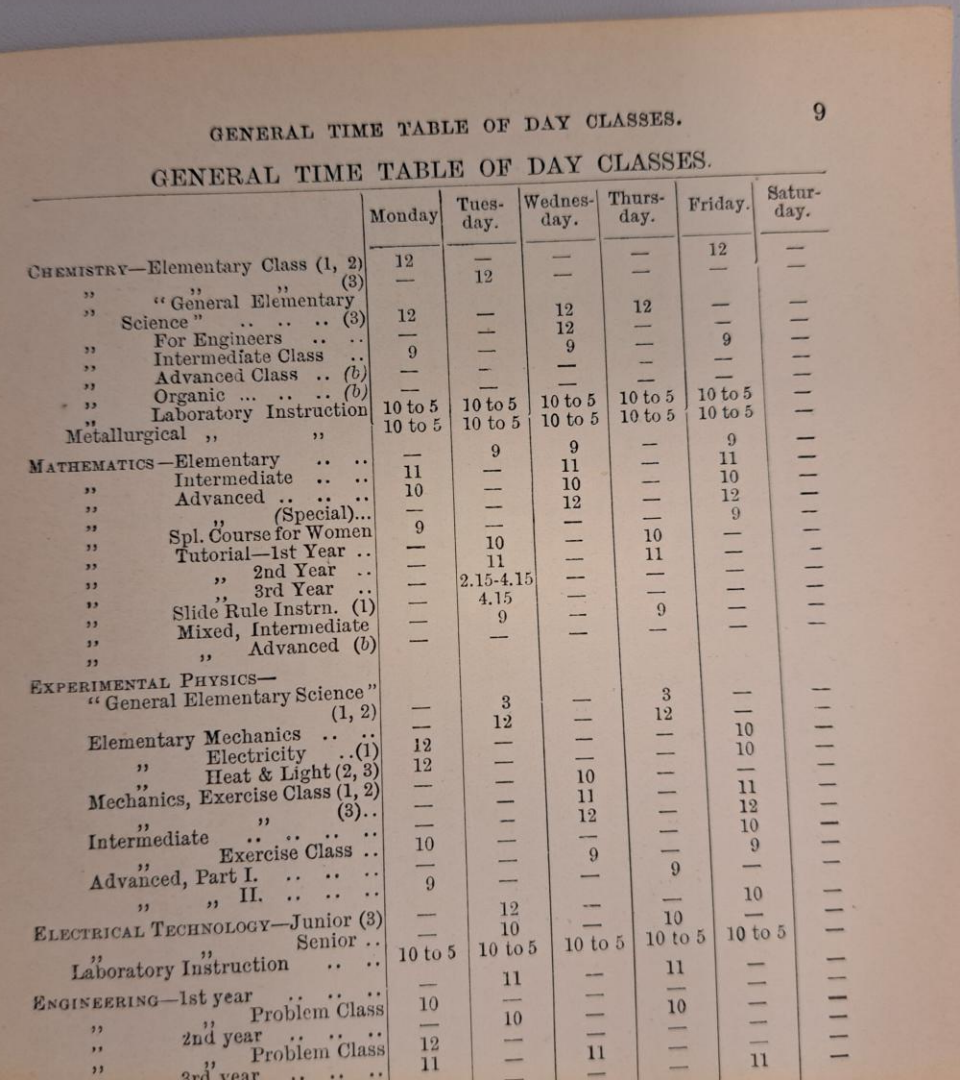
1. Miss Amy Bell.
2. – Emily Pakeman.
3. – Marian Pease.[96]
4. – Rotta Thomas.
5. Mr F.W. Stoddart.[97]
6. Miss Alice Meadon.
7. – Eleanor Killand.

With the condition that Miss Bell, Miss Meadon and Miss Killand attend the elementary Mathematical lectures.

… though not without controversy! [K60]

I find that the Council scholarships were thrown open to both sexes. Five young men, seven young women applied. One of the former qualified; six of the latter [57]. Of the women chosen one or two (as yet uncertain) do not mean to hold them. I believe the Council are rather vexed at this female preponderance, and Miss Winkworth says she is being asked whether 'Bristol has not opened a new college for women'.

I went today to a lecture by the History Professor Mr Rowley. It was the first lecture of the new University College. The audience consisted almost entirely of women. This shows that the work of our Association for the Higher Education of Women has really done something in the place; but for the interests of the new College I hardly think it satisfactory.



GENERAL TIME TABLE OF DAY CLASSES. 9

GENERAL TIME TABLE OF DAY CLASSES.

	Monday	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.
CHEMISTRY—Elementary Class (1, 2)	12	—	—	—	12	—
,, ,, ,, (3)	—	12	—	—	—	—
,, "General Elementary Science" .. .. .. (3)	12	—	12	12	—	—
,, For Engineers	—	—	12	—	—	—
,, Intermediate Class ..	9	—	9	—	9	—
,, Advanced Class .. (b)	—	—	—	—	—	—
,, Organic ... . (b)	—	—	—	—	—	—
,, Laboratory Instruction	10 to 5	10 to 5	10 to 5	10 to 5	10 to 5	—
Metallurgical ,, ,,	10 to 5	10 to 5	10 to 5	10 to 5	10 to 5	—
MATHEMATICS—Elementary	—	9	9	—	9	—
,, Intermediate	11	—	11	—	11	—
,, Advanced	10	—	10	—	10	—
,, ,, (Special)...	—	—	12	—	12	—
,, Spl. Course for Women	9	—	—	—	9	—
,, Tutorial—1st Year ..	—	10	—	10	—	—
,, ,, 2nd Year ..	—	11	—	11	—	—
,, ,, 3rd Year ..	—	2.15-4.15	—	—	—	—
,, Slide Rule Instrn. (1)	—	4.15	—	—	—	—
,, Mixed, Intermediate	—	9	—	9	—	—
,, ,, Advanced (b)	—	—	—	—	—	—
EXPERIMENTAL PHYSICS—						
"General Elementary Science" (1, 2)	—	3	—	3	—	—
Elementary Mechanics	—	12	—	12	—	—
,, Electricity ..(1)	12	—	—	—	10	—
,, Heat & Light (2, 3)	12	—	—	—	10	—
,, Mechanics, Exercise Class (1, 2)	—	—	10	—	—	—
,, ,, (3)..	—	—	11	—	11	—
Intermediate	—	—	12	—	12	—
,, Exercise Class ..	—	—	—	—	10	—
Advanced, Part I.	10	—	9	—	9	—
,, ,, II.	—	—	—	9	—	—
ELECTRICAL TECHNOLOGY—Junior (3)	9	—	—	—	10	—
,, Senior ..	—	12	—	10	—	—
,, Laboratory Instruction	—	10	—	—	—	—
ENGINEERING—1st year	10 to 5	10 to 5	10 to 5	10 to 5	10 to 5	—
,, ,, Problem Class	—	11	—	11	—	—
,, 2nd year	10	—	—	—	—	—
,, ,, Problem Class	—	10	—	10	—	—
,, 3rd year	12	—	—	—	—	—
	11	—	11	—	11	—

Quiet timetable!

(1901-2 student handbook)

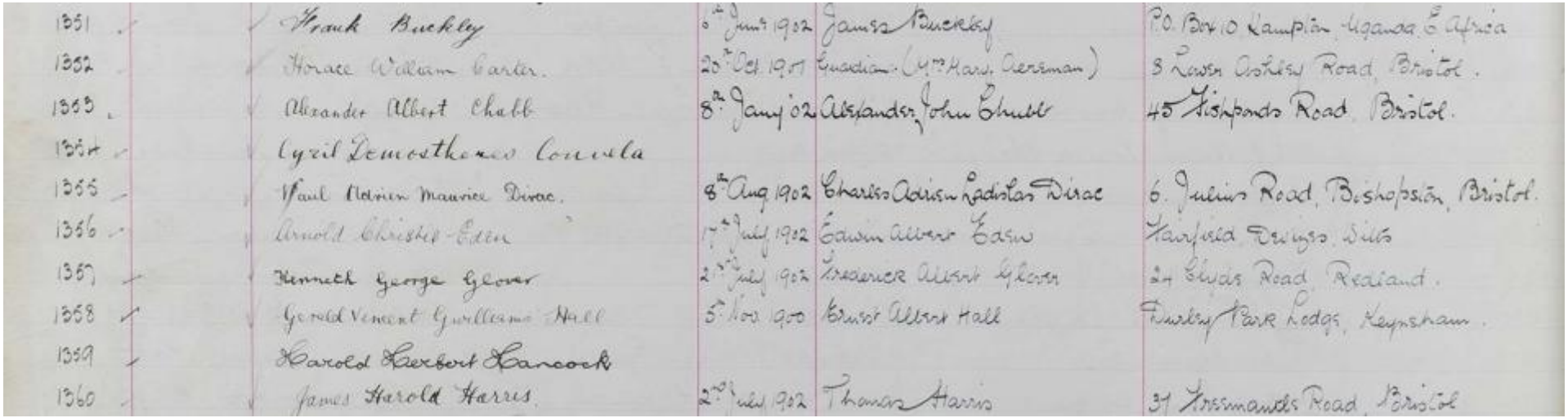
All at 32 Park Row (1876 photo) [DM-247-9]



02

Paul Dirac (1902-1984)

Register of undergraduates [DM2287-6]



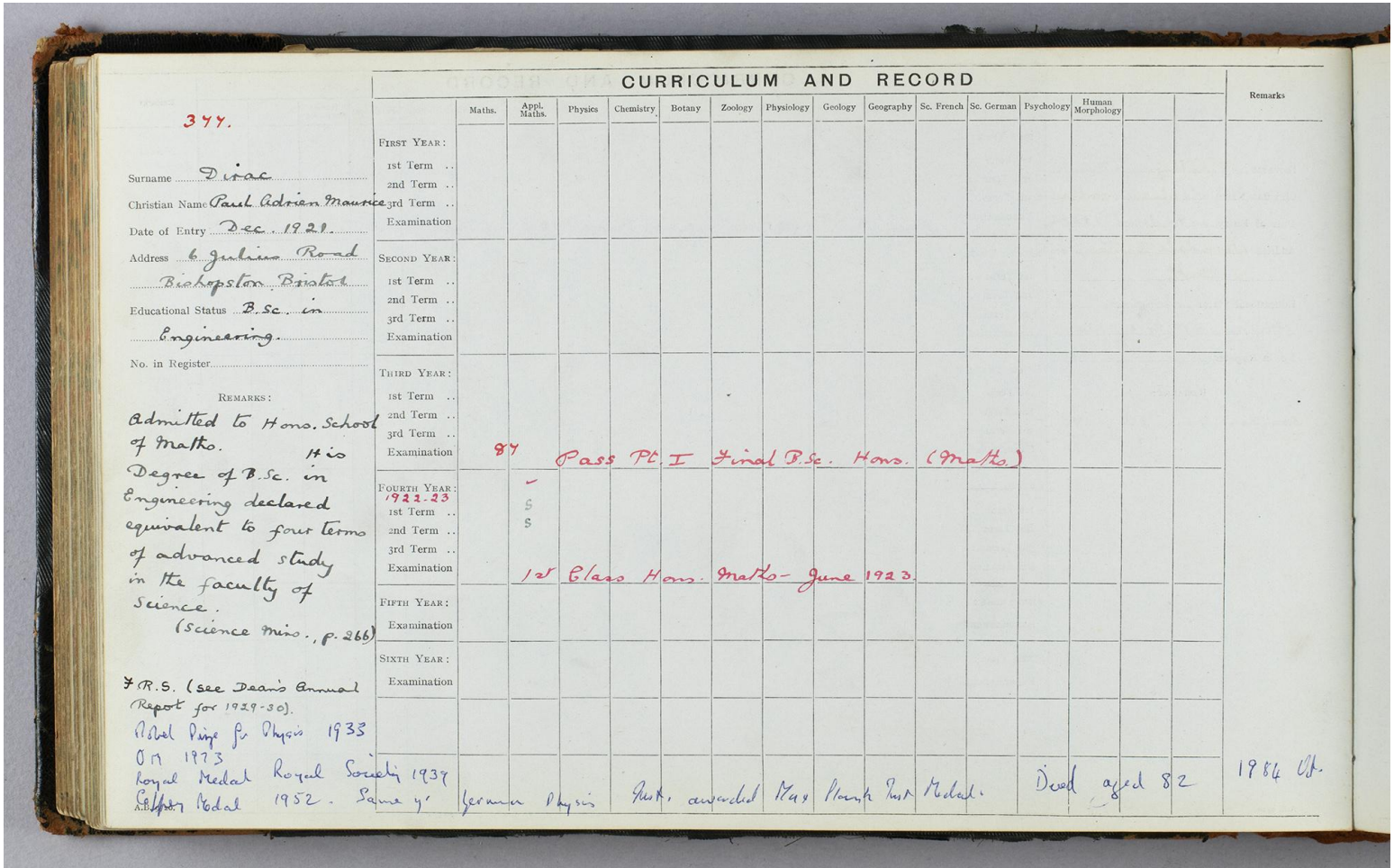
1351	✓	Frank Buckley	6th June 1902	James Buckley	P.O. Box 10 Kampala, Uganda E. Africa
1352		Horace William Carter.	20th Oct. 1901	Guardian (Mrs. Hars. Cleeman)	3 Lower Ashley Road, Bristol.
1353	✓	Alexander Albert Chubb	8th Jany '02	Alexander John Chubb	45 Fishponds Road, Bristol.
1354	✓	Cyril Demosthenes Coucela			
1355	✓	Paul Adrien Maurice Dirac.	8th Aug 1902	Charles Adrien Ladislas Dirac	6. Julius Road, Bishopston, Bristol.
1356	✓	Arnold Christie-Eden	17th July 1902	Edwin Alfred Eden	Fairfield Downs, Wells
1357	✓	Kenneth George Glover	21st July 1902	Frederick Albert Glover	24 Elmdale Road, Redland.
1358	✓	Gerald Vincent Guillaume Hall	5th Nov 1900	Ernest Albert Hall	Pinkney Park Lodge, Keynsham.
1359	✓	Harold Herbert Hancock			
1360	✓	James Harold Harris	2nd July 1902	Thomas Harris	31 Freemantle Road, Bristol

Paul Dirac [DM365-283]

- Grew up in Bishopston.
- Already earned Bristol BSc in Electrical Engineering (1921).
- Won Cambridge place, lacked funding.
- Given free place in Maths, exempted from first year.
- Graduated with a First (1923).
- Cambridge PhD in Physics (1926 – another anniversary!).
- FRS (1930), Nobel Prize in Physics (1933), Order of Merit (1973).



Dirac's student record [DM2067-2]



377.

Surname Dirac

Christian Name Paul Adrien Maurice

Date of Entry Dec. 1921.

Address 6 Jubilee Road Bishopston, Bristol

Educational Status B.Sc. in Engineering.

No. in Register

REMARKS:

Admitted to Hons. School of Maths. He is Degree of B.Sc. in Engineering declared equivalent to four terms of advanced study in the faculty of Science. (Science Mins., p. 266)

F.R.S. (see Dean's Annual Report for 1929-30).
Nobel Prize for Physics 1933
O.M. 1973
Royal Medal Royal Society 1939
Copley Medal 1952. Same yr German Physics Math. awarded Max Planck Prize Medal.
A.B. Died aged 82

CURRICULUM AND RECORD

	Maths.	Appl. Maths.	Physics	Chemistry	Botany	Zoology	Physiology	Geology	Geography	Sc. French	Sc. German	Psychology	Human Morphology			Remarks
FIRST YEAR:																
1st Term ..																
2nd Term ..																
3rd Term ..																
Examination																
SECOND YEAR:																
1st Term ..																
2nd Term ..																
3rd Term ..																
Examination																
THIRD YEAR:																
1st Term ..																
2nd Term ..																
3rd Term ..																
Examination	84		Pass Pt. I Final B.Sc. Hons. (Maths.)													
FOURTH YEAR: 1922-23		–														
1st Term ..		S														
2nd Term ..		S														
3rd Term ..																
Examination		1st Class Hons. Maths – June 1923.														
FIFTH YEAR:																
Examination																
SIXTH YEAR:																
Examination																

1984 Ob.

Dirac's exam paper [FSU_1989009_B7_F19_02]

N.B.—Tie book and foolscap together through the perforation.

UNIVERSITY OF BRISTOL.

Candidate's Name P. A. M. Dirac.

Examination

Title of Paper

Date of Examination 192

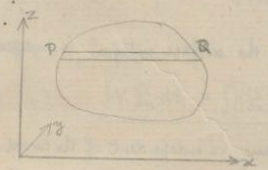
Number of Supplementary Foolscap Sheets attached hereto

Ques. 4.

Gauss' Theorem connecting volume and surface integrals states that, if u v and w are the components of a vector and are continuous

$$\iint (lu + mv + nw)\,dS = \iiint \left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}\right) dx\,dy\,dz$$

where the triple integral is taken over any volume, and the surface integral is taken over the closed surface bounding the volume, l m n being the dir. cos. of the outward normal to the surface.



To prove the theorem, divide the volume into strips parallel to the axis of x, and consider the contribution to the volume integral of a strip PQ

$$\iiint_{PQ} \frac{\partial u}{\partial x}\,dx\,dy\,dz = \delta y\,dz\;\delta y\,\delta z \int \frac{\partial u}{\partial x}\,dx$$

$$= \delta y\,\delta z\,(u_Q - u_P)$$

where $\delta y\,\delta z$ is the cross section of the strip

But $\delta S_Q = \frac{1}{l_Q}\,\delta y\,\delta z$ and $\delta S_P = -\frac{1}{l_P}\,\delta y\,\delta z$

$$\therefore \iiint_{\text{strip } PQ} \frac{\partial u}{\partial x}\,dx\,dy\,dz = l_Q u_Q\,\delta S_Q + l_P u_P\,\delta S_P$$

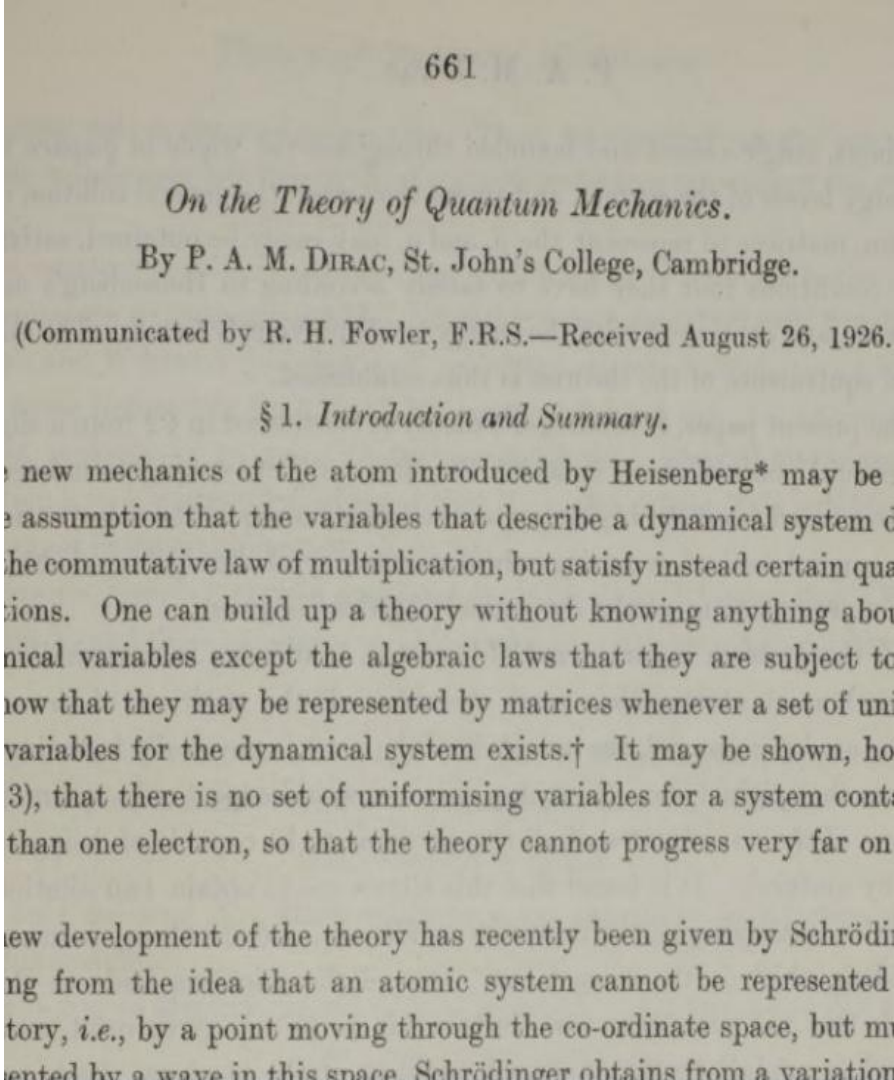
Summing for all the strips

$$\iiint_{\text{volume } V} \frac{\partial u}{\partial x}\,dx\,dy\,dz = \iint_{\text{bounding surface}} lu\,dS$$

Dirac's contributions

- Helped create new subject of quantum mechanics.
- *1926: Proceedings of Royal Society* (PhD!) paper gave new mathematical formulation of Heisenberg's work.
- 1926: derived the Fermi-Dirac distribution for the energy of electrons,
- 1928: formulated the Dirac equation for the electron (implies existence of antimatter):

$$(i\hbar\alpha \cdot \nabla + \beta mc)\,\psi(t,x) = i\frac{\hbar}{c}\frac{\partial}{\partial t}\psi(t,x).$$



661

On the Theory of Quantum Mechanics.

By P. A. M. Dirac, St. John's College, Cambridge.

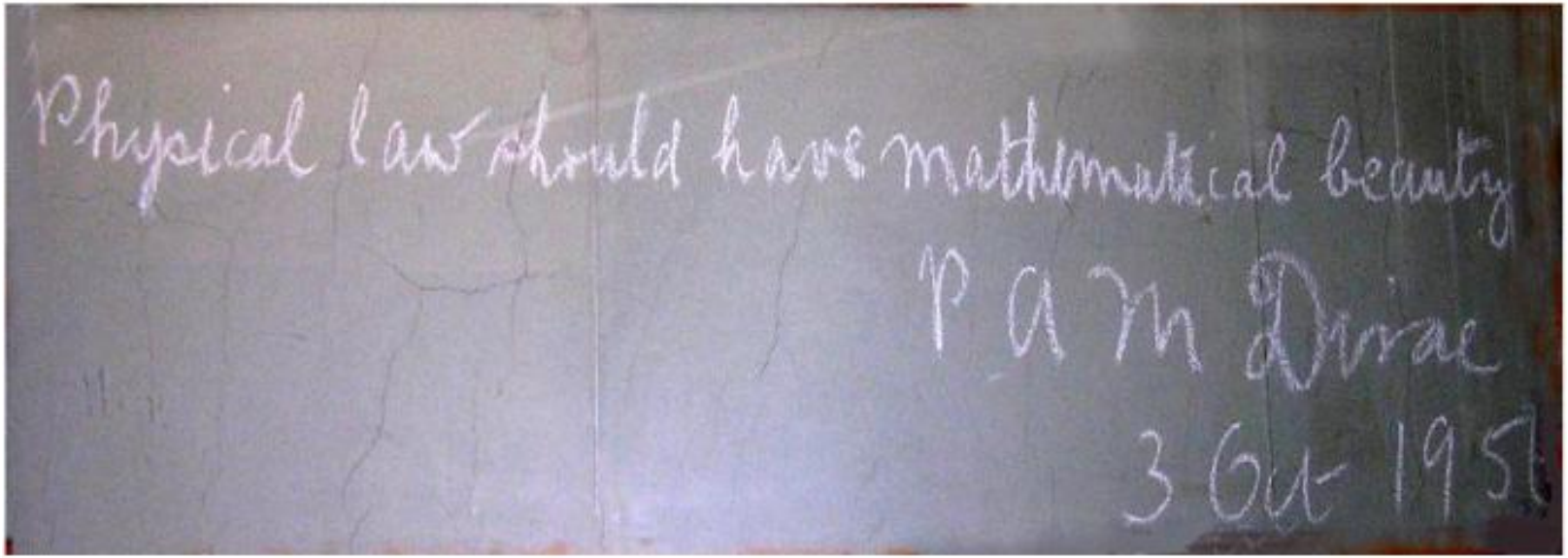
(Communicated by R. H. Fowler, F.R.S.—Received August 26, 1926.

§ 1. *Introduction and Summary.*

new mechanics of the atom introduced by Heisenberg* may be
assumption that the variables that describe a dynamical system
he commutative law of multiplication, but satisfy instead certain qua
ions. One can build up a theory without knowing anything abou
nical variables except the algebraic laws that they are subject to
ow that they may be represented by matrices whenever a set of uni
variables for the dynamical system exists.† It may be shown, ho
3), that there is no set of uniformising variables for a system cont
than one electron, so that the theory cannot progress very far on

ew development of the theory has recently been given by Schrödi
ng from the idea that an atomic system cannot be represented
tory, *i.e.*, by a point moving through the co-ordinate space, but m
ented by a wave in this space. Schrödinger obtains from a variation

Moscow State University blackboard



"*Physical law should have mathematical beauty*" (P.A.M. Dirac, 1956)

Order matters

- Start with the number 5:
  a) If you add 3 and then double it you get 16,
  b) If you double it and then add 3 you get 13.
- The difference between a) and b) is 3.
- (Same wherever you start).
- We say that adding and doubling are **non-commuting** operations.
- “Add 3 then double” minus “double then add 3” is interesting object.
- In mathematical notation: “[double, add 3] = 3”.
- These constructions lie at the heart of quantum mechanics.

What Dirac learned from Bristol Maths

- “Shortly before 9 a.m. on Mondays, Wednesdays and Fridays, Dirac was in his seat, awaiting the next episode of Fraser’s teaching of a special kind of mathematics, known as projective geometry” [GF, p.48]
- “During his mathematics degree, Dirac encountered the ideas of William Hamilton … if one quaternion is multiplied by a second, the result is different from the result obtained if the second is multiplied by the first” [GF, p.50]
- “Dirac also heard about Hamilton’s reformulation of Newton’s laws of mechanics … The key to Hamilton’s technique was a special kind of object … the Hamiltonian, as it became known” [GF, p.50]

- “Unlike Heisenberg, who had never come across non-commuting quantities before, Dirac was well acquainted with them – from his studies of quaternions, … , and from his extensive studies of projective geometry, which also features such relationships” [GF, p.85]

… and where it took him (1926 paper)

If $a = b$ is an identity, we can deduce, since $aX = bX$ and $Xa = Xb$, that

$$aX - Xa = bX - Xb,$$

or

$$[a, X] = [b, X].$$

Thus we can equate the Poisson bracket of either side of an identity with an arbitrary quantity, and so our quantum identity is the analogue of an identity on the classical theory. We assume the general equation $xy - yx = ih[x, y]$ and the equations of motion of a dynamical system to be identities.

A dynamical system is specified by a Hamiltonian equation between the variables

$$H(q_r, p_r, t) - W = 0, \tag{3}$$

or more generally

$$F(q_r, p_r, t, W) = 0, \tag{4}$$

and the equations of motion are

$$dx/ds = [x, F],$$

Another lasting contribution: bra-ket notation

A Hilbert-space vector, which was denoted in the old notation by the letter ψ, will now be denoted by a special new symbol $\rangle$. If we are concerned with a particular vector, specified by a label, a say, which would be used as a suffix to the ψ in the old notation, we write it $|a\rangle$. It may be that the label is very complicated, consisting of many letters, but we can always write down the vector conveniently in the new notation, simply by enclosing the label between $|$ on the left and $\rangle$ on the right. We have also to deal with another kind of Hilbert-space vector, the conjugate imaginary of the first kind. This was denoted in the old notation by ϕ or $\overline{\psi}$, and will now be denoted by $\langle$. If one of them is specified by a label a, we write it $\langle a|$.



Built into the Fry Building pavement and glass





Ubiquitous notation (Shor's algorithm 1995)

- Dirac's work continues to drive quantum research in Bristol.
- Faculty CREST in Quantum Information, Phasecraft spinout

$$
\begin{aligned}
|00\rangle &\rightarrow |00\rangle \\
|01\rangle &\rightarrow |01\rangle \\
|10\rangle &\rightarrow \tfrac{1}{\sqrt{2}}(|10\rangle + |11\rangle) \\
|11\rangle &\rightarrow \tfrac{1}{\sqrt{2}}(|10\rangle - |11\rangle).
\end{aligned}
\tag{2.2}
$$

Not all truth tables correspond to physically feasible quantum gates, as many truth tables will not give rise to unitary transformations.

A new home ...

- In 1927 Maths moved to third floor of newly-built Physics building.
- W.V.D. Hodge (of Hodge Conjecture fame) had joined in 1926.



03

Hans Heilbronn (1908-1975)

Hans Heilbronn

- Born in Berlin.
- Number Theory PhD Göttingen 1933.
- Jewish scientist forced out by Nazis.
- First moved to Bristol January 1934.
- Cambridge 1935, interred as enemy alien (!) 1940, joined military intelligence.
- Returned to Bristol 1946, became Henry Overton Wills Professor 1949.
- Head of Department 1949-1964.
- Moved to Canada.



Heilbronn's first move to Bristol [CF p.120-1]

for half a year'. In mid-December Heilbronn received an invitation from H. R. Hassé, Head of the Department of Mathematics in the University of Bristol, offering hospitality and financial support, and on 16 January 1934 he came to Bristol, taking up residence at a students' hall of residence, Wills Hall, 'where the food is excellent (if you don't compare it with Trinity of course)', as he writes in a letter to H. Davenport.

Working with Academic Assistance Council (AAC)

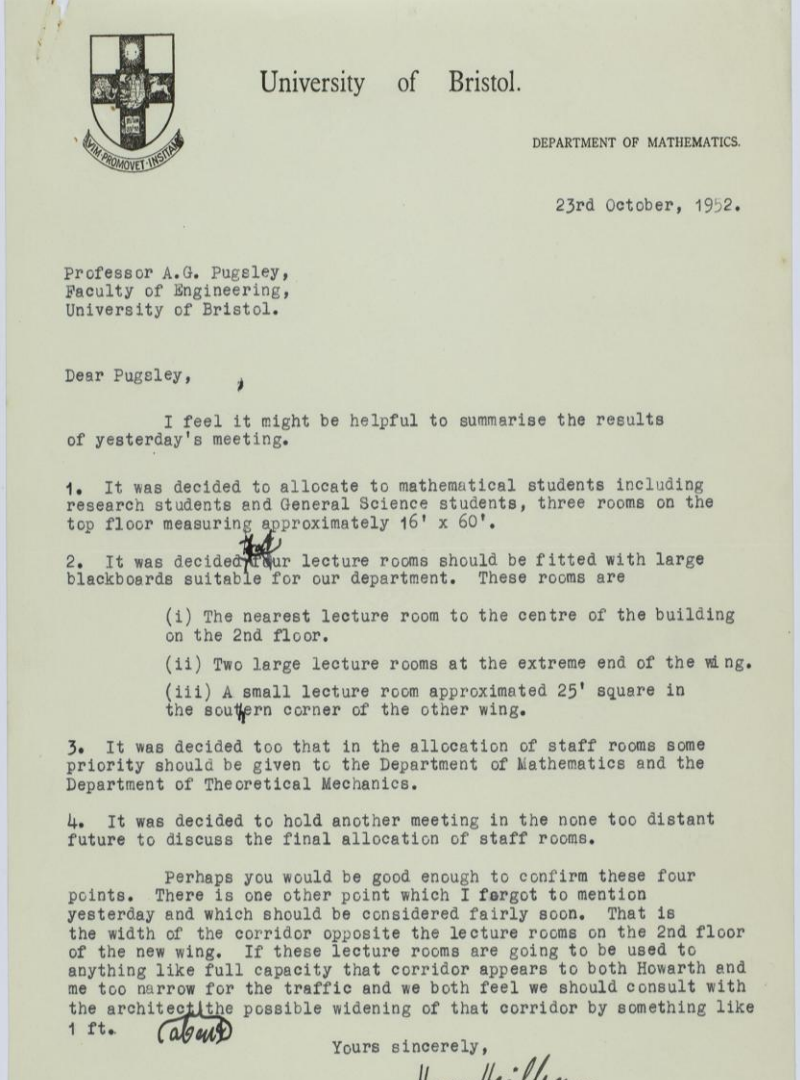
In the meantime Mordell had been active in Manchester and the Vice-Chancellor writes from there offering accommodation for Heilbronn, but asking for financial support from the A.A.C. Not unexpectedly the A.A.C., notoriously short of funds, had to say no. Similar regretful negative replies went to Hardy, and to Heilbronn himself. Then, on 8 November, Hassé from Bristol says: 'I am considering the possibility of inviting a young German Jewish mathematician to take a temporary position.' He mentions Heilbronn, following a recommendation by Harold Bohr, and adds that he has asked the Jewish community in Bristol to help raise £200 p.a. 'Can the A.A.C. help?' Reply on 10 November: 'Our annual grant is £182'—plus a conditional offer of considering a small supplement if most of the £182 can be raised locally. On 29 November another letter from Hassé: 'The Jewish community will give £75 for three years'—so he needs another £107. No reply recorded. Then on 11 December, Hassé once more with better news: 'I now have promises for a further £65 p.a. mainly from university colleagues', with hopes for more. It is not clear where the balance came from, but in any case Heilbronn got his invitation.

Factorising numbers

- Used to whole numbers factoring into primes in a unique way.
- For example, 150 = 2 x 3 x 5 x 5.
- But other number systems are possible.
- Can consider complex numbers, things like $2 + 3\sqrt{-1}$.
- Creates a consistent arithmetic, things seem to work OK.
- Can think about numbers of the form $a + b\sqrt{-d}$ for some *d.*
- Things can get weird!
- For $d = 5$ it turns out $6 = 2 \times 3 = \left(1 + \sqrt{-5}\right)\left(1 - \sqrt{-5}\right)$.
- And all these values act like primes (can't split up more).

Major contributions 1934-5 (with Linfoot)

- Famous old problem (Gauss 1801): which *d* values have the unique factorisation property?
- People knew **at least nine** nice *d* (3, 4, 7, 8, 11, 19, 43, 67, 163).
- But could there be many (infinitely?) more?
- Heilbronn and Linfoot proved there were **at most ten** nice *d.*
- (Turns out there are exactly nine).
- Heilbronn also proved things get very nasty for big *d.*



University of Bristol.

DEPARTMENT OF MATHEMATICS.

23rd October, 1952.

Professor A.G. Pugsley,
Faculty of Engineering,
University of Bristol.

Dear Pugsley,

I feel it might be helpful to summarise the results of yesterday's meeting.

1. It was decided to allocate to mathematical students including research students and General Science students, three rooms on the top floor measuring approximately 16' x 60'.

2. It was decided four lecture rooms should be fitted with large blackboards suitable for our department. These rooms are

(i) The nearest lecture room to the centre of the building on the 2nd floor.

(ii) Two large lecture rooms at the extreme end of the wing.

(iii) A small lecture room approximated 25' square in the southern corner of the other wing.

3. It was decided too that in the allocation of staff rooms some priority should be given to the Department of Mathematics and the Department of Theoretical Mechanics.

4. It was decided to hold another meeting in the none too distant future to discuss the final allocation of staff rooms.

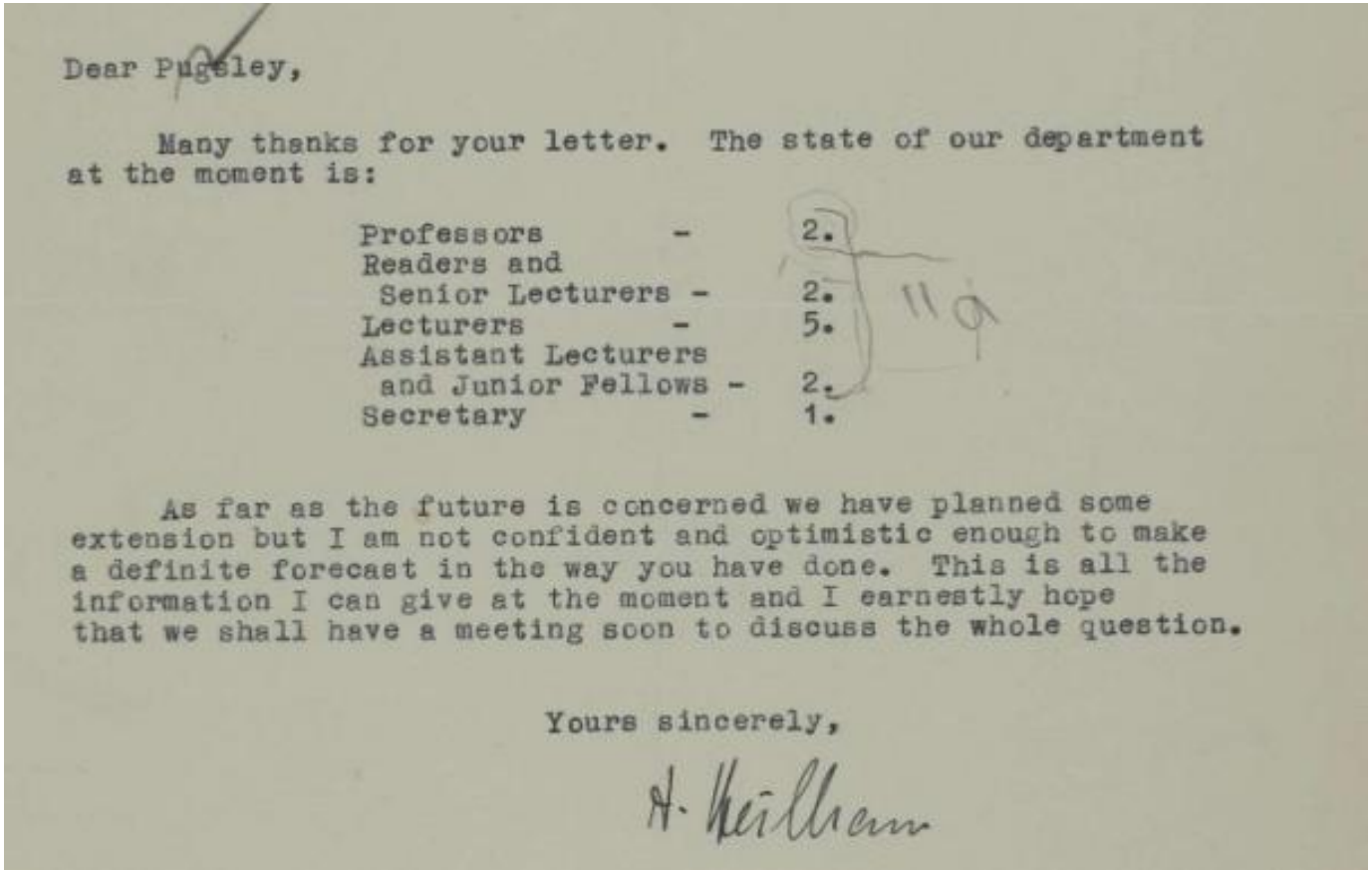
Perhaps you would be good enough to confirm these four points. There is one other point which I forgot to mention yesterday and which should be considered fairly soon. That is the width of the corridor opposite the lecture rooms on the 2nd floor of the new wing. If these lecture rooms are going to be used to anything like full capacity that corridor appears to both Howarth and me too narrow for the traffic and we both feel we should consult with the architect the possible widening of that corridor by something like 1 ft. (about)

Yours sincerely,

Heilbronn's legacy as Head of Department

- 1958 Maths moved to newly-built Queens Building.
- Occupied Eastern end of first and second floors.
- Concerned with blackboards and office spaces (nothing changes!).
- Planning gives snapshot of size of department.
- Correspondence DM1297-B4

Letter from Heilbronn, 9th June 1953 [DM1297-B4]



Dear Pugsley,

Many thanks for your letter. The state of our department at the moment is:

Professors -	2.
Readers and Senior Lecturers -	2.
Lecturers -	5.
Assistant Lecturers and Junior Fellows -	2.
Secretary -	1.

As far as the future is concerned we have planned some extension but I am not confident and optimistic enough to make a definite forecast in the way you have done. This is all the information I can give at the moment and I earnestly hope that we shall have a meeting soon to discuss the whole question.

Yours sincerely,

H. Heilbronn

1953 Mathematical Society photo



FIRST ROW:- MR VINT, DR. STEWARTSON, GRIFFITHS, P. BATH, PROF. HOWARTH, F.B. ELLERBY, PROF. HEILBRONN

J. CAMPBELL, DR. CHESTER, MR. WILKINSON, MR. SHEPHERDSON

Heilbronn's legacy – hiring and mentoring (CF p.124)

During his tenure of the chair of pure mathematics, Heilbronn built up an excellent department in Bristol. He seems to have had his ear to the ground; for example, using his long stays in Cambridge to get to know of the brightest graduates and using his mastery of committees to secure Bristol lectureships for them. Among the appointments for which he was responsible were those of J. C. Shepherdson (at least indirectly), D. A. Burgess, C. Davis, C. Hooley, J. M. Marstrand and E. R. Reifenberg.

During this Bristol period Heilbronn exerted a major influence on mathematicians of the younger generation, which goes well beyond what has become apparent in the printed word. Some measure of his success is the number of former colleagues or students who now hold senior positions.

J. C. Shepherdson, who was to succeed Heilbronn to the chair of pure mathematics and who has made his name in mathematical logic, actually wrote his first paper on a number theoretic problem, suggested by Heilbronn

Heilbronn Institute for Mathematical Research

Key strategic partnership

- Founded in Bristol 2005 as partnership between UK government and maths community.
- Supports maths pipeline and carries out high-quality research to make a difference to national security.

Huge part of UK people pipeline

- Currently 50 postdoctoral fellows across 7 institutions (23 in Bristol).
- Fellows supported into a range of careers in academia (~70%) and industry (~30%).

National mathematics Institute

- 28 PhD students graduated from Heilbronn Doctoral Programme in 2025/26.
- Supports events and focused research activities, attracting outstanding individuals to visit UK.

04

Probability, statistics and AI

Another move (1968): Queens to Ada Lovelace





Henry Overton Wills Professors of Mathematics

- 1919–1949: Henry Ronald Hassé
- 1949–1964: Hans Heilbronn
- 1964–1976: Leslie Howarth
- 1977–1991: John Shepherdson
- 1991–1999: Philip Drazin
- 1999–2003: Bernard Silverman
- 2003–2011: Peter Green
- 2012–2019: Jon Keating
- 2024-: Jens Marklof

Statistics in Bristol recent growth area

- **Statistics top in UK 2001 RAE and top 5 in 2008.**
- **Significant growth due to £4.2m SuSTaIn grant (*"Statistics underpinning Science, Technology and Industry"*, 2006-2016)**
- **COMPASS CDT 2019- recruited five cohorts of PhDs.**
- **Particular focus on computational and Bayesian statistics.**



What is Bayesian statistics?

- Bayesian statistics builds on Bayes' Theorem in probability.
- Tool to deal with **conditional probability** (e.g. might like to know "what's the chance I have COVID if I test positive?").
- It gives us a way to flip around the direction (based on the information "what's the chance I test positive if I have COVID?").
- These aren't the same - but can get from one to the other with care.
- (See my post "Lateral thinking" on bristoliver.substack.com for more).

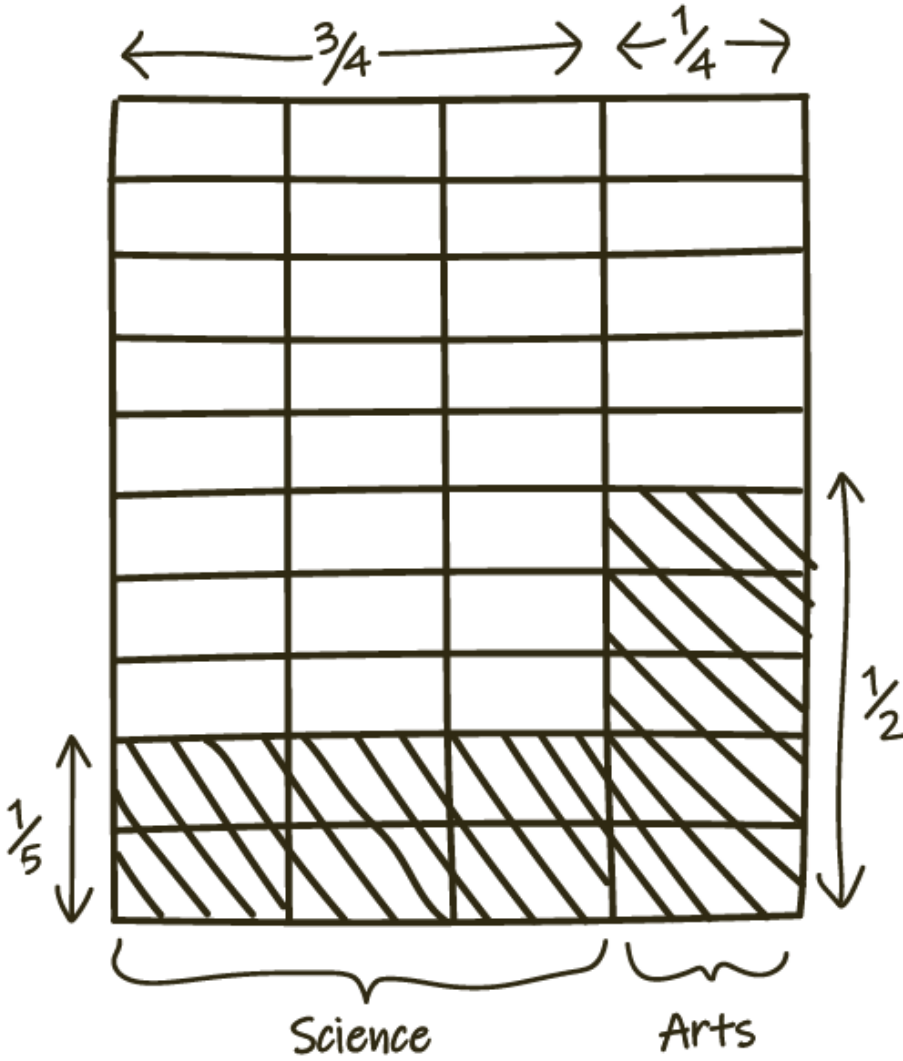
Covid: 82% of positive rapid tests 'were correct'

15 April 2021 · 735 Comments

Numbercrunch p.159

- **75% of students study Science, the rest study Arts.**
- **20% of students who study Science missed their lecture.**
- **50% of students who study Arts missed their lecture.**
- **What proportion of missed lectures involved scientists?**

  - Can use Bayes … or draw a picture!
  - What proportion of shaded rectangles are Science?
  - Can see that it is 6/11.



What is Bayesian statistics?

- Surprisingly powerful tool for thinking about the world.
- Principled framework to update our beliefs using data.
- Take a model “what is the chance of seeing this data if X is true?”
- Flip it over to get “what is the chance that X is true if I see this data?”
- Computations can get pretty intense though!

1.5. The Factor Principle

Nearly all applications of probability to cryptography depend on the *factor principle* (or Bayes' Theorem). This principle may first be illustrated by a simple example. Suppose that one man in five dies of heart failure, and that of the men who die of heart failure two in three die in their beds, but of the men who die from other causes only one in four dies in their beds. (My facts are no doubt hopelessly inaccurate). Now suppose we know that a certain man died in his bed. What is the probability that he died of heart failure? Of all numbering N say we find that

Bayes underpins modern AI

- Lots of problems solved by AI fit in this framework:
- “What is the chance there’s a tumour given this image?”
- “What is the most likely next word given the words so far?”
- You might need a very big computer though!

Note that the training objective for D can be interpreted as maximizing the log-likelihood for estimating the conditional probability $P(Y = y|\boldsymbol{x})$, where Y indicates whether $\boldsymbol{x}$ comes from p_{data} (with $y = 1$) or from p_g (with $y = 0$). The minimax game in Eq. 1 can now be reformulated as:

Bristol Maths and AI

- Researchers developing new AI methodologies.
- Involved in two multimillion EPSRC-funded AI Hubs (InformedAI and Prob_AI).
- Publishing in top AI venues (21 ICML and NeurIPS papers in last two years).
- COMPASS graduates work in leading AI firms, academia, technology, finance and government.
- Undergraduates taking up placements, internships, forming startups, research bursaries and collaborations.

05

Bristol Maths today

We moved again .. to Fry in 2019 [DM247-11]



UNIVERSITY OF BRISTOL, WOODLAND ROAD ENTRANCE.

Fry built in phases from 1880-1938 [DM257-39]



Fry brought up to date in 2019

- … despite setback of 2018 fire.
- Voronoi screen and new atrium.
- Student study spaces.
- Seminar rooms and of course blackboards!
- Take a tour, enjoy the mathematical artworks.



Research still matters

- Still doing quantum, number theory and statistics.
- But also new areas e.g. ergodic theory, mathematical biology– across five research institutes.
- Community of PhDs, postdocs and staff working together.



Ranked 4th for research in REF 2021, 6th in 2027 *Times* rankings



Staff continue to win London Mathematical Society Prizes

Dr Laura Monk's work ranked in 2025 top 3 maths breakthroughs worldwide



Recent major donation supporting early-career pure mathematicians

17 different undergraduate degrees



Working with a range of industrial and government partners

Our past values still matter to us

Gender balance matters

- Just as first cohort was gender balanced ..
- … we still believe in supporting female careers.
- Held Athena SWAN Silver since 2017.
- Staff network and role models through seminars.

Maths is for everyone

- Just as we supported Dirac …
- … we have Access to Bristol and Maths Circles.
- *Mastering Maths* targets Year 12s from non-traditional backgrounds.
- Work with Martingale for postgrad study.

We are international

- Just as we welcomed Heilbronn ..
- … our staff and students come from around the world.
- We've taught recently in AIMS (across Africa), Cambodia, Philippines, Peru and Rwanda
- Our Data Science BSc is now in Mumbai.

Our collaboration network



Some of the graduating class of 2026



Partial list of sources and further reading

- DM Image courtesy of University of Bristol Library, Special Collections
- K C.S. Knighton Editor *Bristol University: From Conception to Foundation* 2019
- FSU Paul A.M. Dirac collection, courtesy of the Florida State University Libraries, Special Collections and Archives https://repository.lib.fsu.edu/islandora/object/fsu:diraccol
- GF Graham Farmelo *The Strangest Man: The Hidden Life of Paul Dirac, Quantum Genius* 2009
- CF J.W.S. Cassels, A. Fröhlich; *Hans Arnold Heilbronn, 8 October 1908 - 28 April 1975*. Biogr. Mems Fell. R. Soc., 1 November 1976; (22): 119–135.

Thank you

Enjoy the rest of the day – see the exhibits, take a tour of Fry

Lecture slides available via QR code:

University of BRISTOL