



UNIVERSITY OF
OXFORD



Haberdashers'
ADAMS

ENGINEERING: AN ACADEMIC ROUTE

Thomas Cross ON
DPhil Student, Oxford Thermofluids
14th November 2022



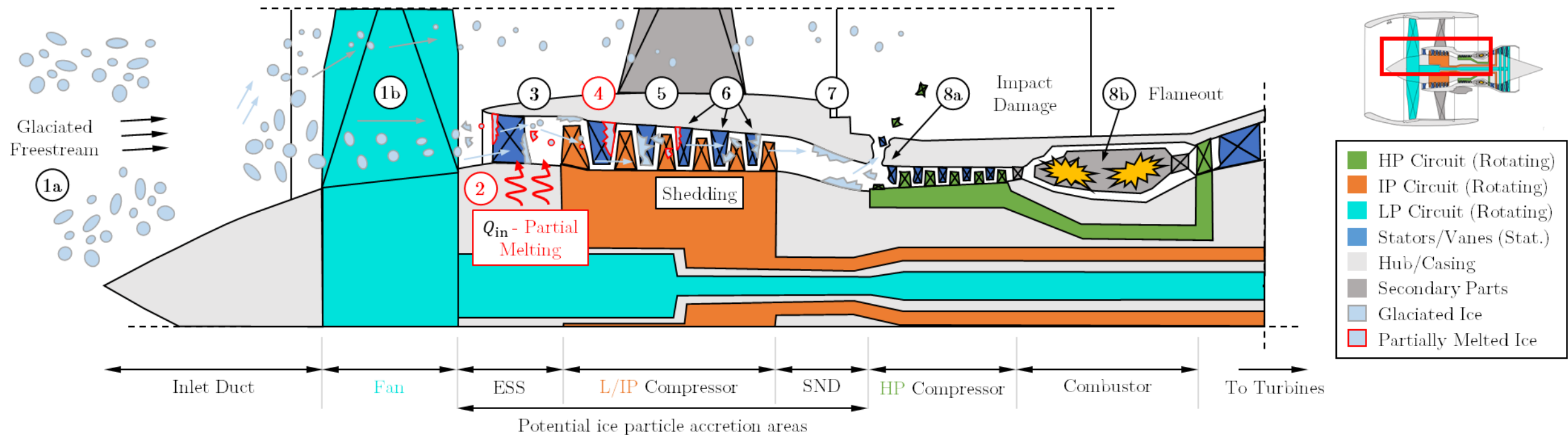
ABOUT ME



Thomas JS Cross
DPhil Student, *EPSRC Turbo CDT*
thomas.cross@trinity.ox.ac.uk

- Adams' Grammar 2010-17 (**Darwin**)
 - CCF, Dixon Cup, Orchestra, Band, U13 C's Rugby...
 - Arkwright Scholarship
- Student Member of the RAeS, IMechE & AIAA
- Imperial College London, MEng Aero. 2017-21
Faculty Student Union President
 - High-Speed Propulsion & Aerothermodynamics
 - Science Policy
 - Computational Fluid Dynamics
- Cambridge (Wolfson), MRes Turbomachinery 2021-22
- Oxford (Trinity), PhD Gas Turbine Icing 2022-26

GLACIATED ICING IN GAS TURBINE COMPRESSORS



1. Entry event
 - a) Ingestion
 - b) Conditioning
2. Partial melting

3. Surface interaction
4. Through-blade heat transfer
5. Shedding
6. Repetition

7. Swan-necked Ducts
8. Engine Damage
 - a) Shed Impact
 - b) Instability

PRESENTATION STRUCTURE

Engineering at University

- University structure and types of degrees, funding
 - Degree's vs Degree Apprenticeships
 - Engineering Subjects at university
- Choosing Universities, with examples
 - Applications & UCAS
- The University Experience
 - Student Life
- Good Advice & how to spend Summers
- References and Links, Discussion

Share Link: <https://github.com/Tjcross31/TCAdamsTalk.git>

Boxes

In these boxes you'll find examples and other useful things

The most important point on a slide will be **highlighted**



Imperial's Formula Student Team (2018)

THE ACADEMY

The University Structure, Degrees & Engineering Disciplines

UNIVERSITY STRUCTURE

- 14th Century Italy education for young nobles
 - Centres for research and advanced teaching
 - Now large corporate entities with multiple spin-out companies and industrial collaborations
- Some have *Colleges* (Oxbridge, Durham) but most do not
- You may find certain tiering:
 - “The Russell Group” and “The Golden Triangle”
- A springboard to more advanced technical and managerial
 - Established firms
 - Start-Ups
- They have resources for Student Support / Pastoral Care
 - **Visit them on Open Days**

Box 1 – Imperial

Students

18,264 full-time (2019-20)

10,457 – undergraduate

4,009 – taught postgraduate

3,798 – research postgraduate

Students from 132 countries

Staff

3,731 academic and research staff

4,217 support staff

Alumni

Over 190,000 alumni

WHAT COUNTS AS ENGINEERING

Applied Disciplines arising from **STEM** subjects
(**Science, Technology, Engineering and Maths/Medicine**):

- Aerospace/Aeronautical Engineering
- Bio-Engineering
- Chemical & Process/Systems Engineering
- Civil Engineering
- Computing, Computer Science & Data Science*
- Design Engineering
- Electrical & Electronic Engineering (EEE)
- General Engineering
- Mechanical, Automotive & Mechatronic Engineering



Chemical Engineering Pilot Plant
(Imperial)

DEGREE TYPES

UG – Undergraduate (i.e. *first* degrees), often involve year in Industry or placement years

- BEng (3yrs) – Bachelors of Engineering
- **MEng (4yrs)** – Integrated Master's of Engineering

Box 2 - Ben's Advice

Apply to MEng courses even if not thinking of it, greater module choice etc.

PGT/PGR – Taught/Research Postgraduate (Second Degrees)

- MSc (1 or 2yrs) – Master's of Science
- PhD/DPhil (3 or 4yrs) – Doctor of Philosophy
- EngD (4yrs+) – Engineering Doctorate, Industrially focussed

NEW: CDT – Centre for Doctoral Training (1+3 MRes/PhD)

- MRes (1yr) – Master's of Research, a PG course offered as part of a CDT

FUNDING

Costs (UG – 2023 Updated):

- As a UK (Home) student you are guaranteed a tuition fee loan (£9,250+) for 3 or 4 years for your *first* undergraduate degree
- Sliding scale for maintenance (living) loan of up to £9,706 (£12,667 in London), based on family income, min ~£4,000
- **Think of a student loan more as a graduate tax**
- Some unis also provide additional bursaries, grants, scholarships. Imperial was **very** good for this, offering all home students £2-5000 a year
- As a postgrad you are entitled to a single loan ~£11,000 , however often you will be paid a stipend to study

Box 3 – Tom's First Year (2017-18)

Tuition Fees

£9250 in ~~£9250 out~~

(You never see this amount)

Maintenance - London

£8000 in £6000 out – rent, low

£3000 out – living and food

Other Contributions

£4000 in – Imperial Bursary

£2000 in – Haberdashers' Scholarship

£1000 in – Parental Contribution

£1000 out – partying and stuff?

(This is not average i.e. bursaries)

Overall:

£+15,000 in £-10,000 out £+5000 Net

COMPARISON TO DEGREE APPRENTICESHIPS

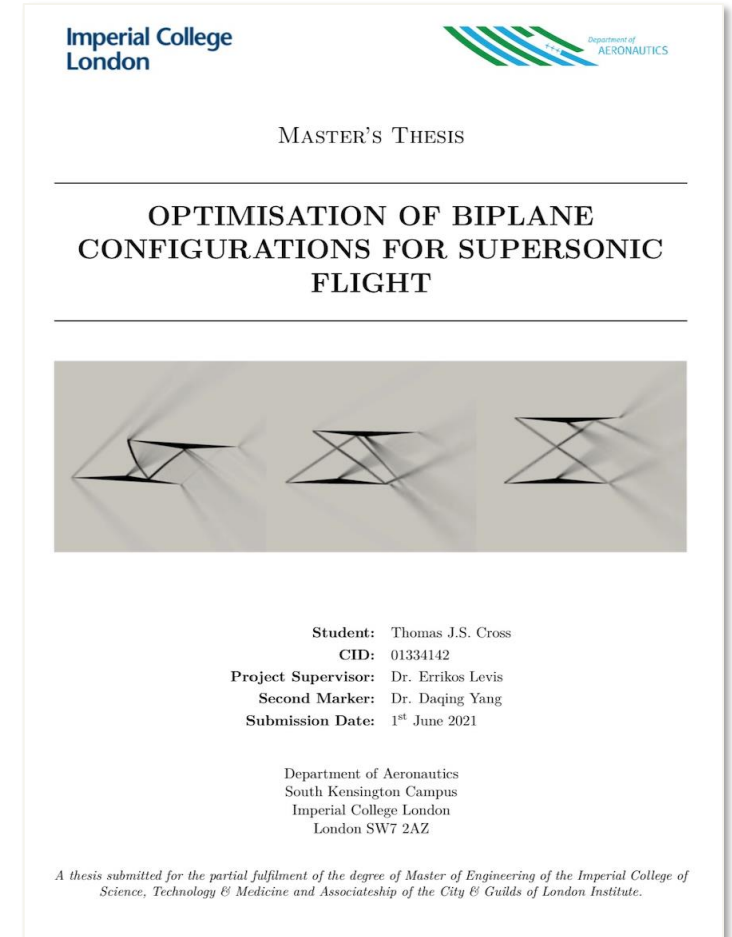
- Apprenticeships generally paired with newer universities, local Uni's, living at home
- Lower starting salary with lower rise-rates
- May get money on the job but...
 - You (potentially) cut yourself off from academia, Masters degree's and some positions in companies (that req. CEng)
 - Internal company qualifications may not be externally recognised
 - You may be tied to one employer, regardless of what they say they've made an investment in you – if you'd done the same would you make it beneficial for people to leave?

*“A lot of people aren't sure
what they want to do ...
an apprenticeship is not
the right way to go if that's
the case ”*

~ Sastin Codling-Loidi, Degree-Apprentice
at BAE Systems

BENEFITS OF AN ENGINEERING DEGREE

- Well regarded and well respected qualifications
- You're not “stuck in one thing for ages” there's scope to change and leave the field entirely if you wish
 - Many doorways that open after
 - Well paid careers and stability vs. Arts & Social Sciences, especially in EU/US
 - Entrepreneurial mindset
- Routes to professional engineering through Chartership (CEng) and other recognised bodies (IMechE, IChemE etc.)
- The extra-curriculum component and personal development before world of work are some of the most valuable components



LOCATIONS & APPLICATIONS

What to do and Where (and When!)

- 1) Do you like it there?
- 2) Where is it?
- 3) What does it offer?

CHOOSING UNIVERSITIES

- Look at the Course Content
 - Ranking and **Accreditation**
 - Industrial Links, Facilities
 - Job/Research prospects
- Entry requirements
 - Oxbridge & Imperial
 - Russell Group i.e. Bristol, Bath, Sheffield
- Some universities hold particular specialties (Automotive Eng. at Oxford-Brookes)
 - Loughborough†

Box 4 - Chemical Engineering at Imperial Guardian University Guide 2021:

2nd in UK

Facilities:

Onsite Pilot plant (only university in the UK to have one), used for Carbon Capture

Accreditation: IChemE

Entry Requirements: A*A*A

Student Satisfaction: 89.4%

Job Prospects:

Previously oil and gas, now renewables and process engineering, consultancy... a lot of consultancy



APPLICATIONS & UCAS

A-Levels

- Maths, Further Maths, Physics, Chemistry (Check the courses requirements). You'll almost definitely need Maths & Physics
- Further Maths, or a knowledge of it will make your life **a lot** easier

Apply Early - Even if you're not going for Oxbridge

- This puts you in the top of the pile, allows for earlier interviews etc.

Personal Statement (The process at Adams' is very good)

- Show you are engaged in the wider subject area

Uni's, like jobs, shouldn't expect you to be the finished article – just show your good potential. There's no shame in delaying or taking a gap year, some of the most interesting people I know have

- Age of students in a cohort may well be 17-35

THE STUDENT EXPERIENCE™

Studying Engineering this may be a little different

STUDENT LIFE

For engineering studying is a lot of work - especially in the first 2 years when you're learning theory

- Grading systems are different! 70% for a *first* (top grade)
- You'll have to **manage time** around Projects










The key thing that differentiates university is the social life

- There is all this amazing stuff you *can* get up to i.e. clubs, societies, meeting people from other Universities etc.
- **Work Hard, Play Hard**

'Studenting' has changed a bit even since I first started:

- On the whole people don't drink as much as they used to



VK	Sloane Square	9:00am
○	Wetherspoons Victoria  	9:15am
○	The Albert 	10:00am
○	St Stephen's Tavern	10:30am
	Westminster	
○	The Sherlock Holmes  	11:00am
	Embankment	
	The George	11:30am
	Temple	
	The Blackfriar	12:00pm
	Blackfriars	
○	The Sugarloaf	12:30pm
	Mansion House	
○	Sir John Hawkshaw  	1:00pm
	Cannon Street	
○	The Monument 	2:00pm
	Monument	
○	The Liberty Bounds 	2:30pm
	Tower Hill	
	The Hoop and Grapes	3:00pm
	Aldgate	

STUDENT LIFE



A good night in the Union (Bar) – Note the Tankard!



Aeronautics Christmas Party 2018

STUDENT LIFE



Adams'/Flat BBQ



Flat Beer-Can Chicken



Imperial's Graduation Ceremony 2019

COLLATED ADVICE

Things I wish I'd have known...

GET A BIKE

- Keep organised notes – you’ll thank yourself later, remember what Mr Latter says (7Ps)
- Keep an Engineering Logbook, treat it like a Jedi would his lightsabre and note everything
- Ask Questions
- Make every moment of the lecture and interactions you have count
- Network, Network, Network
 - LinkedIn “[Even on the toilet](#)¹” – this platform can also serve as your online CV... keep it up to date
 - “Your Network, is your Net-Worth”

*“Heavens,
Don’t just type the lectures
into word Documents”*

~ Oliver Hulland ON,
Computer Science, Lancaster



MONEY SAVING TIPS

- You'll get to know where the cheapest food places, and the most *efficient* bars are
- Book keeping: budget and monitor your spending, give yourself an allowance per week for things like 'fun'
 - Cook in, instead of eating takeaway; it's cheaper and a life skill too, and social
 - Buy in bulk: consider a weekly shop
 - Buy 'own label' i.e. Asda SmartPrice rather than *Heinz Beanz*
- Time is it's own currency

“Live like a Student for 4 years, and a King after

-

Live like a King for 4 years, and a Student after”

~ Some adaption of a phrase that boils down to living the student life while you are a student, as opposed to after

INTERNSHIPS & BUSY SUMMERS

INTERNAL – SENSITIVE



NightFighter® Series RF Jammer Testing Campaign

Friday 14th August 2020
Thomas Cross¹, Luke Rickard²

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PHD RESEARCH PROPOSAL

Shock-Boundary Layer Interactions (SBLI) in Soft Landings on Planetary Bodies

Thomas Cross¹
MEng Student, Aeronautical Engineering, Department of Aeronautics,
Imperial College London, South Kensington, London, SW7 2AZ
¹thomas.cross17@imperial.ac.uk

Subject of Research

This project would aim to characterise the nature of interactions (SBLI) between a landing spacecraft's nozzle exhaust plume (at Mach 6) and the emerging boundary layer and regolith (planetary soil) on the surface of the body it is descending towards. This interaction causes havoc on the surface [1,2,3]; contaminating samples [4], but also has implications on spacecraft descent control [5]. Surface material disruption may even cause breathing issues for manned crews [6].

This research will address the fundamental questions of what interactions happen when a high-speed jet impinges onto the insulating surface (bed) of a planetoid in a vacuum. This work is at the forefront of original aerospace science, and newer than being highly publishable is vital to advancing space missions [7].

The primary deliverable of this project is to fill industrial knowledge gaps concerning the of the flow physics, structures, particulate shear forces, and pressure fields surrounding the landing region and subsequent dispersal effects on the regolith.

As an extension research may also explore the test domain to evaluate what the effect on the regolith may be. To this end various trials [2,8] have been conducted to match characteristics such as the specific gravity of this material to allow testing to be scaled from Martian/airless body gravities to that of earth. Hence it will be of relevant interest to evaluate the effects of firing the various nozzles (for martian, lunar, etc flow rates) within a test chamber into buckets of low diameter glass spheres and crushed walnut shells to measure the impact and observe the Fluid-Structure Interactions (FSI) present.

Importance of Research & Investigation

A truly alien environment, detailed studies of plume-regolith interactions in a vacuum are of value to planned sample return missions to asteroids with months-long travel times in which sample contamination cannot be tolerated. In addition, the data developed through experiments will be of importance to future mars missions where supersonic retro-propulsion [9] (SRP) is viewed as being the only feasible method of softly landing the increased payload sizes [6] needed for human habitation.

Substantial European Space Agency (ESA) funding has been invested into a specialised low-pressure testing facility at the University of Glasgow [10], built some two years ago, showing industrial commitment to a series of long lifetime projects. Research into vacuum-based plume-regolith interactions using the facilities available forms the next logical point of evaluation. The datasets generated will be used as diagnostic tools to validate and advance numerical codes developed by ESA, hence are of critical industrial importance and will play a role in mission planning [11].

Engagement with Recent Study

The author has shown considerable interest and initiative in related fields with compressible flows and supersonic aircraft design forming the mainstay of his Masters' Thesis: *The Design of Jointed Supersonic UAVs for Busemann Type Flight* [12]. Hypersonic flow

physics was also studied in the fourth-year elective course: *Aerothermodynamics of Re-entry Vehicles and Launchers* [13] under Dr P. Bruce [14], a field leader in experimental aerodynamics.

Methodology & Approach

The unique challenge that will be present throughout this project will be due to the extrema in pressures present. The vacuum environment leads to outgassing in most materials [15] and this may also limit the use of traditional techniques such as Schlieren Imaging [16] due to a distinct lack pressure gradients in a vacuum. Likewise, the unique environment means that classical pressure tapping's cannot be used [17]. There are many unknowns, and a lot of techniques may not work, hence there is the need to try everything, available and 'write the book' on conducting high speed experiments at reduced pressures.

State-of-the-Art experimental methodologies are being considered including pressure sensitive paints [18,19] and nano-particle sensors [20]. In addition, classical techniques for high-speed gas dynamics will be sought to be used such as high-speed Particle-Image Velocimetry [21,22] (PIV) through a Germanium Window as well as the scope for employing specialised computational methods for rarefied gases i.e. DSMC [23,24].

The Vacuum test chamber and buffer tank arrangement (72m³ combined) funded by ESA at Glasgow are unique in Europe and will allow for a plethora of cutting-edge experiments in high-speed rarefied gas dynamics across pressure scales (Atmospheric to 0.001atm [10]). With the facilities setup, continuous and pulsating firing can be conducted while negating the propellant mass flow by active suction to maintain simulated atmospheric conditions.

Both this proposal and the facility of concern operate on the newest frontier of experimental aerothermodynamics, both in terms of what it is thought can be synthesised and how to achieve it: The design of the nozzle system alone required a custom heat exchanger to be designed [10] to operate in a Vacuum and rapidly heat the exit gas to some 1000K in a fraction of a second for Reynolds Number Matching [25].

As mentioned, both significant financial and engineering investment has been made in these facilities [26], which are perfect for the proposed research. The scope for investigations with this facility are truly only what the operator can conceive.

Discussion of Primary Sources

Hypersonics is somewhat of a niche field, however there are some related textbooks [27,28] and at least one work dedicated to SBLI [29], these will form the core sources that will be used in addition to experimental guidance. In addition, a bank of related papers has been compiled by the high-speed group at the University of Glasgow. Physical examples of high-speed objects and full-scale landers are also present in London's Science Museum [30].

Secondary Sources

Numerous secondary sources exist on NASA websites. A summary list of material mentioned and additional papers is printed overlaid.

1

Imperial College
London



Compressible Flow Lecture Demonstration Rig

Thomas Cross¹ & Raihaan Usman^{1,2} (Dr Peter Johnson^{3*})
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Abstract

A setup for demonstrating compressible flow phenomena to first- and second-year undergraduate students is designed and presented. Using elements of 15 bar high-pressure storage tank from previous student projects, a legacy Amrad variable supersonic nozzle, and a custom data acquisition hardware, an open-circuit blowdown type supersonic wind tunnel is constructed. The tunnel allows for the creation, measuring and observation of high-speed gas dynamics namely the formation of normal shockwaves across a variable area working section, from which a pressure-rise and stagnation pressure deficit occurs.

Pressure readings are recorded via a bed of ultraminiature Kulite pressure transducers and are contrasted with theoretical readings that can be shown to students a priori, viewable through a python webapp. This functionality also allows students to design and test their own 3D printed working sections in the tunnel, recording their own data for later follow up work. The entire rig is designed to be portable and operated in short runs at the front of a typical lecture theatre, but is extendable to much more mature studies of shockwaves, notable Shock-Boundary-Layer Interactions (SBLI's).

Abbreviations

Thomas Cross (TC)
Raihaan Usman (RU)
Peter Johnson (PJ)
Keith Blackney – Thermofluids Workshop Technician (KB) keith.blackney@imperial.ac.uk
Steve Bancroft – Kulite UK Sales Rep. (SB) steve.bancroft@kulite.eu



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Examples are the authors own work. General advice here is to take time off in the summers, and the whole summer for the first and last year. But in years 2 and 3 try to stay busy and build your own personal portfolio; consider summer placements, internships or research placements.

Slide 22

QUESTIONS?

Discussion welcomed

REFS. & CONTRIBUTORS (FEEL FREE TO FOLLOW UP)

- Imperial College London (2021) *This is Imperial*. Introductory College PowerPoint Presentation
- Imperial College London (2017) A Day in the Life of Imperial. YouTube Video, Available at: https://www.youtube.com/watch?v=QUBsf-2GX5s&ab_channel=ImperialCollegeLondon [Date Accessed: 14/09/2021]
- Imperial College Careers Advice Service (2021) CVs and Resumes. Available at: <https://www.imperial.ac.uk/careers/applications-and-interviews/cv/> [Date Accessed: 14/09/2021]
- Oli Hulland ON (Computing, Lancaster)
- Sastin Codling-Loidi ON (Degree-Apprentice, BAE)
- Ben Dent BEng ACGI (Computing, Imperial 21') – Software Engineer at BlackRock

APPENDICES

Additional Useful Material

CHOOSING UNIVERSITIES (EXAMPLES)

Engineering Discipline	Some Good Choices
Aerospace/Aeronautical	Imperial, Southampton, Loughborough, Sheffield, Liverpool, Delft (Netherlands), NEW Nottingham
Bio & Bio-Mechanical	Oxford, UCL, Warwick, Southampton
Chemical & Process/Systems	Cambridge, Imperial, Manchester, Nottingham
Civil & the Built Environment	UCL, Imperial, Leeds, Sheffield
Computing, Computer Science & Data Science*	Imperial, Warwick, Edinburgh, Manchester
Design	RCA, Dyson (Imperial), Brunel
Electrical & Electronic (EEE)	Imperial, Queen Marys, Lancaster
General	Cambridge, Oxford, Bristol
Mechanical & Mechatronic	Bath, Bristol, UCL, Imperial, Manchester, Durham

CV ADVICE (NOT NEEDED FOR UCAS)

- You, your background and achievements
- **Tailor this to what you're applying for** (Jobs, Academia)
 - Check the job/opportunity requirements
- For Engineering stuffs 2 pages is alright, for Consulting perhaps consider 1 page
- Make it easy to read, and dated, with **figures** (quantify)
 - Separate the sections and use **bold** for subtitles
 - Include your education and work experience/history in reverse chronological order
- Make every word have value, and show what **you** did and the impact **you** had in the role

THOMAS J. S. CROSS

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Tel: (+44)7342 642259 · email: thomas.cross17@imperial.ac.uk · in: thomas-j-cross/

EDUCATION

Imperial College London MEng Aeronautical Engineering *Oct 2017 - Present*
Electives include: Computational Fluid Dynamics, Computational Aerodynamics, Exotic Propulsion, Aeroelastic Control, Aerothermodynamics of Re-Entry Vehicles & Launchers (SBLI) *Current Mark: 68%*
Haberdashers' Adams' (Formerly Adams' Grammar) *Sept 2011 - June 2017*
A-Levels: Chemistry, Physics, Mathematics, Further Mathematics, Geology (AS) *Grades: A*A*A*A*A*
GCSEs: Including Triple Science, Mathematics and English *Grades: 10 A*s, 1 A*
Arkwright Scholarship for Engineering & Technical Design *Awarded 2015*

EXPERIENCE & VOLUNTARY SERVICE

President, City & Guilds College Union *Mar 2019 - Nov 2019*
Imperial College Union
· Elected to represent and advocate for 6,300 Undergraduate and Postgraduate Engineering students
· Worked within Imperial College Union to shape policy; liaised with the highest levels of College to ensure the student voice is core to their decision-making process
· Secured the highest annual grant from the Faculty of Engineering to date (£13,000) an increase of £3,000 from the year prior
· Strategised with 17 clubs and societies to aid in boosting membership numbers and furthering their offerings

Guildsheet Editor, City & Guilds College Union *Oct 2017 - Jul 2019*
Imperial College Union
· Conceptualised, created and distributed a 54-page magazine produced in Adobe InDesign, informing Imperial engineering students about current events within the College and the Union: www.cgcun.net/guildsheet
· Achieved Imperial College and City & Guilds College Union Colours in recognition of service to the Union.

WORK EXPERIENCE

Technical Intern *Aug - Sept 2020*
SteelRock Technologies *Newport, Gwent*
· Design of UAV flight controllers, low observability technology, and non-destructive RF Counter-UAV systems

CAD Technician & Temporary Site Manager *July - Sept 2017, Aug - Sept 2018*
Bowson Engineering Ltd. *Stoke-on-Trent*
· Interned at a light engineering company specialising in punching, bending, welding and powder coating
· Drew up new designs, generating nested DXF Files for a CNC Punch, as well as manning a Break Press
· Managed the quotation and ordering, overhauled and implemented COSHH Health and Safety recommendations on site

PROJECT

Novel Unmanned Synchropter for the Aerial Recover of Falling Rocket Stages *Jun - Jul 2020*
Supervisors: Dr. M. Ribera-Vincent & Dr. E. Lewis *Grade: 78%*
· Worked within a team of 50 students to develop a wholly reusable launch system for Low Earth Orbit Satellites
· Utilised a novel remote piloted intermeshing helicopter to recover the descending rocket stages
· Produced a detailed technical report of the rotorcraft's systems and transmission
· Submitted abstract to the Royal Aeronautical Society's (RAeS) Annual Rotorcraft Conference.
· Awarded Centenary Prize for top mark in Project. Overview: www.youtube.com/watch?v=mO13a_Nhg

Aerospace Vehicle & Airframe Design *Oct 2019 - Mar 2020*
Academics Responsible: Dr. E. Lewis & Prof. L. Inamci
· Synthesis of design for a 50-passenger regional jet liner for short-haul flights from empirical data
· Structural layout determined from first principles and analysed performance before presented to academics
· Additional finite element campaign of a Fowler-flap component

Design & Manufacture of a Small-Scale Wind Turbine *Oct 2018 - Jun 2019*
Academics Responsible: Dr. P. Bruce, Dr. R. Hewson & Prof. M. Graham *Grade: 76%*
· In depth design study a small-scale 3D-Printed horizontal-axis wind turbine with novel Box-Wing features
· Power extraction was then validated by in-situ wind tunnel testing including smoke tracing

REFERENCES AVAILABLE ON REQUEST

“A DAY IN THE LIFE OF IMPERIAL”



FOR PARENTS

- What are the *Digs* like, will you be in halls?
 - They're alright (see next slide!) you'll most likely be in halls in 1st Yr
- What are the private accommodation options?
 - Shared flats, houses, complexes, room-sharing. This is really what you do from 2nd Yr
- Is the Accommodation suitable?
 - Some are utterly beautiful, but costs. Others are dives. It's all about what you're prepared to put up with or what bothers you: Landlords have **legal obligations** to provide habitable buildings.
- What are the range of prices?
 - Rents vary but a good ballpark figure is £160 per week anywhere (some can be £200+)
- Get in contact with someone in the university, and ask them what things are **really** like
 - Speak to someone in the second or third year, they've been there and will know

ACCOMMODATION (STUDENT HALLS)



Example shown is Imperial's North Acton Halls, the Woodward Buildings, which I rented in First and Second Year

ACCOMMODATION (PRIVATE ACCOM, FLAT)



Example shown in on Melina Rd., Shepherd's Bush, and was the property I rented with two other students in 2020