Candidate evidence

Sciences: Interdisciplinary Project

Proposal

Candidate name									
SCN									
Centre name									
Assessor name									
Project title	DEVELOPMENT OF THE AERODYNAMICS OF FORMULA ONE CARS AND THE IMPACT FROM THESE DEVELOPMENTS								
Chosen subject	☐ Expressive Arts ☐ Languages × Sciences ☐ Social Sciences								

Project outline *(what it is you want to do and how will you go about it)*

I will be researching how aerodynamics in F1 cars has developed through the history of racing and the impact that these developments have had. Such as reducing carbon emissions as well as making the cars greener and more eco-friendly. I will do this by arranging meetings and consultations with parties that are involved in the racing business which will help me to gather information and develop my understanding of my aim. I will also conduct research in university libraries etc. To further my understanding of the principles behind aerodynamics and F1 cars. By researching how aerodynamics have been applied it will show me how it makes the cars more cost efficient due to decreased drag which in turn decreases tyre wear as well as decreasing the volume of fuel used which will decrease overall costs and make the cars more eco-friendly due to less carbon dioxide emissions.

Reasons for choosing this project *(e.g., personal interest, future plans, links to other subjects you are studying/ have studied)*

I am interested in pursuing a career in the engineering field and completing this science baccalaureate will help me to be more involved in the field of engineering and give me an insight into how things work within the companies in the field of engineering. It is mainly my keen interest in physics which has led me to pick this as my topic for my project as physics has always grabbed my attention over the other sciences available in my school and is overall just my favourite. I will also be able to utilize my modelling and design skills from graphical communication to understand the technical drawings and models used in the F1. My knowledge of mathematics up to advanced higher level will also be useful as to understand the equations used in the development of aerodynamics and F1 cars.

The broad contexts this project will cover are

☐	Citizenship	×	Enterprise	☐	Employability
×	Economic development	×	Sustainable development		

Learning environments I will access are

- School and university libraries
- The internet- (https://www.mclaren.com, https://www.schoolofraceengineering.co.uk/f1-aerodynamics/ etc.)
- In person (if available) and online meetings with professionals

How I will use my knowledge of my chosen subject area

I will use my prior knowledge of aerodynamics - which includes knowledge such as increasing tyre grip through increased friction and downforce from the effects of aerodynamics which allows for turning at higher speeds decreasing the overall time needed to complete a lap - as well as what I have newly learned and researched – such as knowledge concerning Bernoulli's equations and vortices etc. - to create and give a presentation on how an understanding of aerodynamics is applied within the F1 industry and how it has developed and affected the future of racing.

The skills I will develop and/or improve in the course of this project are:
(carry out a short analysis of your current strengths and weaknesses in the skills areas below and how you think your project will allow you to develop and/or improve these skills)

application of subject knowledge and understanding

- I will be able to apply my knowledge and understanding of graphical communication, maths and physics to explain how the aerodynamics of F1 cars have developed.
- I will have to learn and understand about new aerodynamic principles as well to be able to fully understand the field of aerodynamics

research skills – analysis and evaluation

- I will create and hand out/post online a survey and then collect in the results and evaluate what they mean
- I will also have to complete research on the internet - on websites and in person – through interviews and books, and select the relevant information according to my chosen topic of aerodynamics

interpersonal skills – negotiation and collaboration

- I will have to be able to prepare and carry out an interview collecting relevant information and will have to develop interviewing skills
- I will also have to ask my friends, family and others to complete my survey

planning: time, resource and information management

- I will be creating a Gantt chart to ensure I stick to my deadlines and finish my work
- I will also be cataloguing whenever I complete work and will keep my information collected in one place

independent learning – autonomy and challenge in own learning

- I think working on my own and doing independent research, planning and project development will help me develop essential skills for later in life such as presentation and research skills.

problem solving – critical thinking: logical and creative approaches

- I will have to be logical in thinking about my target audience for my presentation as well as being creative to ensure originality in my report as well as trying to make my presentation as informative and interesting as possible.

presentation skills

- I will have to be confident when presenting and try to make my presentation as interesting as possible to grab my audience's attention and use simplified language when talking about key areas so my audience can value my presentation and chosen topic

self evaluation – recognition of own skills development and future areas for development

- I have already completed a skills audit and will complete more skills audits periodically throughout the year to evaluate my skills development

Assessor feedback to candidate

An interesting topic to be choosing as F1 conduct rigorous testing on aerodynamics amongst other things to improve the efficiency of the car in terms of reducing drag and thus more economical. This will impact everyday life as car companies are all working to become greener. You will need to go in depth to ensure you explain what developments have improved aerodynamics and how this has affected road cars.

Your project will allow you to use your AH Physics and Maths knowledge when dealing with the complex equations relating to friction, downforce an aerodynamics. You have also explained your choice of project in terms of your academic strengths and future study into engineering.

You have identified the skills this project will require and reflected about your current level.

You now need to work on your plan to give detail as to how you will go about completing your research, gathering people's views and contacting various companies/professionals. Remember that you need to access less familiar learning environments and not solely on internet-based research.

Proposal approved	✓	**Further work required**	
Candidate signature		**Date**	Oct 2022

Interdisciplinary Project

Plan

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Project title	DEVELOPMENT OF THE AERODYNAMICS OF FORMULA ONE CARS AND THE IMPACT FROM THESE DEVELOPMENTS								

Is this a group project? yes ☐ no ×

If a group project my individual role or responsibilities will be:

Timescales *(this should be a detailed timeline and any separate spreadsheets or charts should be included as evidence)*

Will be completed on a Gantt chart

Planning *(how you are going to meet the agreed objectives of your project)*

- I will carefully stick to my Gantt chart to guarantee that I complete my tasks on time and progress smoothly throughout the year
- I will carry out research and gather information about aerodynamics and organise it on my computer/logbook
- I will create a survey and distribute it between my friends, family and others who wish to complete it and collect the results and evaluate them
- I will create an informative presentation/report on my chosen topic of aerodynamics and another survey to be completed after my presentation for feedback
- I will carry out weekly meetings with my physics teacher to ensure progress is being made and there I can also ask for help
- I will write down and record when I complete research or tasks in a logbook to record my progress

Resources *(e.g., people, materials, places)*

- Specialists in aerodynamics at The University of Highlands and Islands – Perth College, Glasgow Uni (interviewed three PHD students)
- MIA (Motorsport Industry Association) School of Engineering

- Websites - https://the-mia.com/page/Education , https://www.perth.uhi.ac.uk/ , https://www.nls.uk/digital-resources/, , https://ethos.bl.uk/Home.do;jsessionid=655D4B3239D92A2F28EAE89A6660F6DA
- Students and Family and Friends

Research methods *(e.g., contacting companies, surveys, focus groups, experimentation)*

- I will conduct online research
- I will access resources in my school library
- I will have to contact McLaren, MIA, Perth college and Glasgow Uni to arrange interviews or in person workshops to attend to learn about aerodynamics from experts in the field
- I will have to create a survey and distribute it between peers to collect research material to use in my presentation
- I may arrange to visit the wind tunnel in Glasgow Uni to conduct an experiment on aerodynamics to deepen my understanding of aerodynamics and develop my skills in data gathering and experimentation

Presentation

- **Who do I think will benefit from listening/reading/looking at my presentation of my project findings/product?**

  - F1 fanatics or simply people who are interested in Formula One
  - Younger scientists who are interested in furthering their knowledge of aerodynamics
  - People who want to study physics at university and want to have some prior knowledge about fluid dynamics beforehand

- **What methods are appropriate to my audience(s)** *(e.g., demonstration, presentation software, websites, oral, report, piece of theatre, DVD, wiki/blog or any combination)*

  - Using a PowerPoint presentation and models will be an appropriate method of displaying the information to my audience as the PowerPoint will be visually pleasing to my audience and will attract their attention as well as being visually informative with pictures and information and the models will help me physically display to my audience the improvements to aerodynamics that have been made throughout the history of F1

Dependencies *(what is required for your project to go ahead i.e., reliance on other people or resources, steps in plan that must be completed before starting the next step)*

- Choose a topic
- Conduct research
- Record research
- Complete first draft of proposal
- Finish Proposal
- Complete first draft of plan
- Finish Plan

- Contact contacts
- Arrange interviews
- Conduct interviews
- Create Survey using research
- Distribute Survey
- Collect and evaluate results
- Create presentation
- Present presentation
- Complete project

Contingencies

Any anticipated problems	**My plans for overcoming the anticipated problems.**
• Contacts not responding or not being able to meet in time • Survey participants not providing info or others not completing it • Contacts not providing relevant information • Covid prevents me visiting Glasgow University wind tunnel	• Have backup contacts to provide interviews if main contacts are not available or receive information via email • Find new survey participants to complete it by going to physics clubs or F1 clubs • Conduct more research on the internet to fill the gaps in my knowledge or go to libraries to find information in books or journals • Research aerodynamics/wind tunnel experiments online and/or contact the University staff to interview them

Method for recording my skills development and future areas for improvement

- Weekly meetings - help to document progress and focus on areas of concern or that need improvement
- Skills audit - helps me to accurately identify what stage certain skills area at which will allow me to check if progress has been made at the end of the project
- Logbook – to record whenever I do work or research new areas so I can reference back which will help me to develop my time management and research skills.

Assessor feedback to candidate

Your plan is in good depth with realistic timescales. You have broken the tasks down well in your GANTT chart and you should try to refer to this on a regular basis to keep you on track. Keep your logbook up to date and reflect on the skills developed (or not) whenever you complete a task.

Your dependencies list and GANTT chart show a good understanding of how some tasks are dependent on others.

Good work on identifying potential issues and the contingencies to these – particularly those where you have considered issues around Covid-19. A good outline of how you will monitor your skills development. Maintaining your logbook will allow you to reflect on your progress to identify when you have developed skills. The skills audits you complete should allow you to record your skills development over the whole project.

Plan approved	✓	**Further work required**	
Candidate signature		**Date**	Nov 2022
Assessor signature		**Date**	Nov 2022

Interdisciplinary Project

Presentation of Project Findings/Product

Candidate name	
SCN	
Centre name	
Assessor name	
Project title	DEVELOPMENT OF THE AERODYNAMICS OF FORMULA ONE CARS AND THE IMPACT FROM THESE DEVELOPMENTS

How I presented my project findings *(describe in detail how you presented your project findings and explain the choices you have made with regard to your presentation method(s) and audience(s))*

I presented my findings through a presentation to a select audience that was keen to learn and understand more about the aerodynamics of F1 cars. I found it hard to select an audience due to the nature of my talk targeting a small niche audience within my school and community. To improve my chances of selecting an audience that was interested in my topic I think I could have posted on social media to gather an audience as then the audience would be able to reach out to me rather than I, reaching out to them which would have made it easier to select an audience. To determine what level to pitch my presentation at I created a questionnaire with selective questions which allowed me to accurately identify the level to pitch my presentation at. I did this as I researched information up to university level such as the Navier-Stokes equations as well as Bernoulli's equations and had to decide whether to include them or not due to the level of understanding needed for the equations and the results of my survey led to the decision to not include the Navier-Stokes equations but include one of Bernoulli's as it was more relevant and the level of difficulty was more appropriate for my audience. For my presentation I chose to use to use Prezi which is a web- based tool that allows users to create a presentation using a map layout after it was recommended to me by my teacher however I then had to go and independently learn how to operate and use Prezi. I chose to use Prezi as it allowed me to retain my audience's attention throughout my whole presentation, as Prezi includes built in animations and layouts which made it easier to grab my audience's attention and to present my findings without interruptions. During my presentation I asked questions to my audience regarding my survey – such as asking what aerodynamics is (the definition) as 100% of my audience said they knew what the definition was – and received high level responses from my audience which was

good for keeping them engaged and interested. I also used props in my presentation such as a ball in which I used to demonstrate how a vortex would be formed. At the end of my presentation, I allowed for a brief period of questions which helped to test how deep my knowledge and understanding of aerodynamics as well as allow my audience the option of furthering their knowledge as well. After my presentation I handed out my survey once again to test if my audience had listened and taken in the information from my presentation. I found that my audience, did indeed, retain most of the information from my presentation as all my questions had good responses with my audience telling me that they now know the answers to my questions. One of the major setbacks of my presentation was overcoming any mental barriers associated with presenting to an audience. I thought that I would be worried about presenting being embarrassing or my presentation not flowing correctly however I found that this was not the case due to using my Prezi presentation as a guide which helped my presentation to flow smoothly even without a script which also made my presentation seem more natural and down to earth. I also practiced my presentation a couple of times before the official presentation which was key as I was able to receive feedback on it and make alterations regarding that feedback such as changing font size, type or colour so it is easily read from anywhere in the classroom as well as including any extra information within my presentation that would have a positive impact such as information on wind tunnels which I didn't have a slide on.

Assessor feedback to candidate

See Assessor Report

Candidate signature	**Date**	Feb 2022
Assessor signature	**Date**	Feb 2022

Interdisciplinary Project

Evaluation of project

Candidate name									
SCN									
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Project title	DEVELOPMENT OF THE AERODYNAMICS OF FORMULA ONE CARS AND THE IMPACT FROM THESE DEVELOPMENTS								

How successful has my project been overall? *(Consider the strengths, weaknesses and learning points of your planning, implementation and findings/outcomes giving examples to support your comments)*

My project aim was to research the aerodynamics of Formula One cars and how they have developed throughout the history of Formula One and how they have reduced carbon emissions to make the car greener. I planned to show what changes have been made and what effect they have had through my presentation. I feel I have successfully achieved my aim as I obtained results that show that the aerodynamics of the car have developed with the alterations and additions of new and existing parts. Such as the addition of front/rear wings, bargeboards and diffusers all of which are used to significantly improve the aerodynamics of the car by directing airflow and eliminating and controlling turbulent air which contains vortices (turbulent air that spins about an axis). Due to these changes and the significantly improved aerodynamics the car uses less volume of fuel which decreases the amount of carbon emissions that the cars produce. The car also experiences less tyre wear due to the elimination of most of the drag of the car, from the improved aerodynamics decreasing the drag coefficient of the car, which means that the tyres will have to be replaced less often, less tyres will have to be made and less rubber will have to be extracted from trees making the process more sustainable and both of these facts making the car more eco-friendly and greener.

During the research stage of my project, I ran into setbacks such as when my potential contacts did not reply to my inquiries which led me to become anxious on whether or not I would be able to contact anyone. This led me to change my plan of action and contact new experts in the field of aerodynamics as I explored my options. I went on to contact and conduct an interview with three PHD students from the University of Glasgow who were willing to share their knowledge with me and assist me throughout my project, which greatly benefitted me as they had all of the answers I needed and even gave me simplified explanations of complicated

physics. For my interview on zoom I pre-emptively sent by questions by email so I could have the answers in written format – which considerably helped in simplifying the physics down to an understandable level for my presentation - as well as allowing the three students to prepare answers that they would be ready to chat about which would allow for more time to go in depth about the questions as well as more time for any other questions such as discussing (Alexanders) masters project on the addition of the halo to Formula One cars. Another helpful piece of information that I received from my interview that I referred to earlier was the fact that one of the PHD student's master's projects was on the aerodynamics of F1 cars and the introduction of the halo. Reading this paper helped me to further my knowledge of the aerodynamics and processes needed for my project which greatly assisted me in creating my project as I was able to relate this information to my presentation and simplify it so my audience would be able to understand the information.

One of my main weaknesses during the project at a whole that I was unable to overcome was time management. I did construct a Gantt chart with the intent to follow it at the start of the Project however I quickly fell behind and deviated from the course that I had set myself on the Gannt chart. I would normally say that I fell behind based on my extracurricular activities such as my swimming or rugby but participating in this project has allowed me to identify my strengths as well as my weaknesses and I feel this is a major weakness as I always ended up doing my project on the Sunday before our weekly meetings on a Monday to ensure I was caught up with the tasks I had set. Although, I could have saved myself from a world of building stress and anxiety by sticking to my Gantt chart, I did not. However, I did manage to stay on track to finish my project due to our weekly meetings and using phone reminders which I felt were more helpful than a Gantt chart which I would most definitely omit from my next project. I would instead include my phone calendar as my time management resource as I feel that planning it out on my phone calendar and scheduling reminders at opportune moments when I would be able to complete work would work better for me due to my busy schedule.

Finally, I feel that numerous features of my project were difficult. Such as actually creating the project, contacting and cooperating with experts in my chosen field of research and creating a presentation that would be interesting and captivating for my audience as well as providing relevant information regarding my aim. Nevertheless, I feel as though I have settled in and become more comfortable as I participated in this project and it begins to feel more natural and words start flowing onto the page. I enjoyed interviewing the three PHD student’s from Glasgow University and also enjoyed listening to them give me insight into their PHD project which was simplifying Computational Fluid Dynamics which was relevant to my topic although too advanced for my audience so I had to simplify it down which I found was a challenging yet exciting task as I began to understand more and more of the core physics and maths skills needed for my project.

How effective were my communication methods throughout the project?

One of the hardest parts about my project was contacting experts in the field of aerodynamics as I felt as though they would simply ignore my initial inquiry email as they may have been invested in their own tasks and may view me as an immature school pupil trying to tear them away from their work. After initially panicking after a few of my first contacts did not reply I reached out to the PHD students at Glasgow University and was surprised by how willing to help and genuinely interested that they seemed in my project. The information that I received from them was relevant and extremely important to my project and I am very grateful to them. This gave me a sense of relief as I overcame any worries that I had about interviews and contacts and allowed me to carry on with my project. This experience has provided me with the necessary confidence to do this in future which I feel is a very valuable experience.

I handed out my survey to all of my audience and received valid and valuable responses which I was able to include in my presentation due to their willingness to provide information and excitable attitudes towards my project as a whole. Both of which helped my project to progress smoothly as I received feedback whenever I asked for it. For my survey I had to ensure that the questions were interpreted in the way I wanted them to so that I could receive the right information that would not endanger my project or reduce how trustworthy my results were. I did this by phrasing my questions simply which helped me to simplify down the information in my presentation as well and also using a simple checkbox system for an answer scheme so that it would be easier to answer. I successfully achieved my aim of making it as simplified as possible as my survey participants gave me feedback as such.

I also carried out numerous weekly meetings on a Monday with my teacher which allowed me to evaluate my progress and also make next steps and action points that needed to be completed. I also had the opportunity to ask any questions that I had, solve any problems or difficulties I had when progressing through the project and also received feedback on any work completed allowing me to make changes to have a superior project

Is there any aspect of my project that could be taken further? What might my next steps be?

If I had the opportunity to do this project again, I would most definitely try to overcome the barrier of coronavirus which would hopefully be gone if I had this opportunity. To conduct my interviews in person as well as conduct an experiment at the wind tunnel in Glasgow so I could have experienced it as I feel It would have been a valuable experience as I would have been able to develop my interpersonal skills even further as well as deepen my understanding of aerodynamics.

Candidate signature	**Date**	
Assessor signature	**Date**	

Interdisciplinary Project

Self evaluation of generic and cognitive skills development

Candidate name									
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Project title	DEVELOPMENT OF THE AERODYNAMICS OF FORMULA ONE CARS AND THE IMPACT FROM THESE DEVELOPMENTS								

In evaluating your skills consider the skills analysis which you carried out at the Proposal stage and how you said you would develop and improve these skills. Now refer to your reflective diary/log/blog and feedback you have received and evaluate how you have developed and/or improved these skills through the work on your Interdisciplinary Project.

Application of subject knowledge and understanding

(Think about practical uses for the what you have learned. How did you use your knowledge of your chosen subject area effectively to help you carry out various aspects of your project and how it related to your chosen broad context(s)?)

In my project I have used knowledge from Higher and Advanced Higher Physics and beyond to explain air flow around the car including vortices, Bernoulli's equations and my Graphic Communication skills have helped me to understand the complex diagrams associated with the Formula One car parts that have been changed and allowed me to analyse which sections of the part have changed and why. I have also used my Higher and Advanced Higher Maths skills to understand and derive the complex equations associated with my project such as Bernoulli's and the Navier-Stokes equations.

Through this knowledge I have come to the conclusion that due to the changes made to the particular parts of the Formula One car the result is that a lower volume of fuel is being used as well as less tyre wear which makes the car more eco-friendly and greener as the lower volume of fuel being used means that there will be less carbon emissions and less tyre wear. This results in less tyres having to be made or replaced saving material for example rubber, which comes from trees which helps to decrease the number of trees that must be extracted from in which some result in death of the tree. How does the car produce these changes? Due to the changes, there has been a decrease in the co-efficient of drag due to the elimination or control of turbulent air containing uncontrolled vortices. These vortices can be controlled using the front wing (cascades) to send them under the floor of the car to exponentially increase downforce - due to Bernoulli's principle

which states that an increase in velocity of a fluid occurs simultaneously with a decrease in static pressure. The back wing has been used to slow the air above the car which will then result in an increase in static pressure. This pressure imbalance above and below the car creates a sucking effect; or more commonly known as the ground effect. This increases downforce which allows the car to increase its speed when cornering which subsequently decreases cornering time. Although the increase in downforce slightly increases drag the decrease in cornering times is more beneficial however they have employed a system called the drag reduction system which allows the cars to change the angle of their back wing by an angle within the allotted amount from the regulations which decreases the amount of downforce produced which reduces the drag of the car allowing for higher top speeds. From these effects the total lap time and race time in total is reduced which means a lower volume of fuel is being used. To decrease tyre wear, F1 engineers try to reduce the drag coefficient of the car as much as possible as drag exponentially increases with velocity and as the drag coefficient is reduced this helps to decrease the drag due to the equation F(drag)=0.5CdDAV^2 where Cd is the co-efficient of drag, A is the frontal area, V is velocity and D is air density. As a result of this decreased tyre wear Formula One teams save money as well as materials on acquiring new tyres and this also saves the lives of many trees because, although a low percentage, some trees growth is stunted or they die when rubber is extracted.

Research skills – analysis and evaluation

(Think about the research process. How did you plan, carry out, analyse and evaluate your research? You should evaluate your research methodologies, tools, resources and contacts, data recording and referencing, reliability and usefulness of data.)

At the beginning of my project, I had to decide on what topic area I actually wanted to research and create a project on. Initially I found this challenging as I had a range of topics that I wanted to research but could not decide on which one to focus on. This is one of my major weaknesses, indecisiveness. As it took me a few weeks to decide on a topic this cut my time for my research stage significantly. However, I did manage to complete my research in time due to my effective research methods that I was taught during a lecture on researching and referencing by my school's librarian. The Librarian taught us about a number of things including Harvard referencing and using google scholar. As well as how to search for key words on google and operate databases such as the national libraries of Scotland and England. Before I had completed my research stage, I mapped out everything I wanted to do and ordered them according to when and what stage they needed to be completed at. To assist me throughout my project I went on to create a Gantt chart with my objectives and timescales. However, even though my plan was to stick to me Gantt chart, I found it easier to set myself deadlines and work within them instead. I did this by using my phone calendar although only with light reminders.

Initially I had set out to contact professionals in aerodynamics at Perth College as well as the Motorsport Industry Association (MIA). However, I did not receive any replies from Perth college and the individuals at MIA were volunteers which meant they were not allowed to disclose their details to me which was unfortunate. This

led on to me contacting the three wonderful PHD students at Glasgow University who happily obliged to sharing their knowledge in the field of aerodynamics with me. Especially _ who was extremely enthusiastic with me and keen for me to continue studying physics up to university level even enticing me to apply to Glasgow university. My plan was semi-successful as although I had to make alterations to my initial plan to ensure my project was successful, I was able to complete my research within my deadlines even without referring to my Gantt chart due to my phone reminders as well as the weekly meetings that I had with my teacher which helped me develop my time management skills to the point where I only needed my phone and not the Gantt chart. In future if I did not have a teacher to help me throughout my project, I would have to include more frequent and detailed reminders on my phones calendar to make my project more structured and easier to follow which would allow me to progress through my project quickly and efficiently.

Throughout my project I conducted a multitude of research. I started off by browsing through journals, websites and books to gather surface information that I required and then began to search the web for experts that I could contact through e-mail and arrange interviews with to gather more in-depth information than my surface info which would allow me to ask questions on what I wasn't able to find initially. Most of the information that I acquired was from my interview with the three PHD students from Glasgow University as all three of them were well versed in aerodynamics and had all the answers to my physics and maths related questions which then left more time to go into depth about other questions that I had. This was due to the fact that I had pre-emptively sent ahead my interview questions allowing the PHD students to prepare their answers beforehand and know the general idea of what I was going to ask. This displayed how my lateral thinking had developed through the project as I had never done this before. Any information that I had collected while researching was stored on a document in my one drive on glow. This allowed this information to be easily accessed anywhere with a stable internet connection which allowed me to collaborate my work at home with my work at school easily. To ensure I did not lose any of this information I had saved multiple copies of my research to my school computer and personal computer at home to keep it safe. I had also bookmarked any source that I had used on my computer and stored it in my logbook as well as any side notes that I needed.

I had chosen to do a survey, so I was able to gather some preliminary information about my audience before I created my presentation as to know what level to pitch this at. This was extremely helpful as it allowed me to know how to simplify knowledge down to an understandable level so that my audience would be able to retain the information I presented as well as stay interested in my presentation and not let their attention waver. I chose my audience by selecting individuals that were interested either in physics or maths, or Formula One and then explaining to them about my project and what I was trying to achieve and then seeing if they were interested in coming along to my presentation. This was very tedious as I had to gather a large pool of people to survey myself personally to see if they were intrigued by my project and then hand out the survey.

While I included lots of information in my presentation, I mainly included information that I learned from the three PHD students as I felt that this was the most reliable

and trustworthy information that I had. Before including this information in my project and presentation I went on to cross reference this information with the sources I had found online. One of my most important sources was from another student's project from England. He also did a project on aerodynamics which was very useful for me as I was able to use his sources to collect information (https://thegsaljournal.com/2020/06/28/aerodynamics-in-formula-1/amp/). Some of the information that I collected from other sources was scrapped as I did not know how reliable the information was as there was not a lot of sources on the webpages that I acquired the information from. Collecting the results of my survey and analysing them was a simple task. This was because I decided to use survey monkey which I discovered when trying to look for ways to survey my audience. I had to teach myself how to use the software but other than that survey monkey collected and presented the results of my survey in percentage form making it very easy to analyse and include these statistics in my presentation.

Interpersonal skills – negotiate and collaborate

(Think about how you considered other peoples' views/feedback, discussed issues of concern, reached a solution where needed, adjusted your approach in response to a situation/environment, showed positive self-belief and had the confidence to offer and ask for support.)

At the start of my project, I had a rough idea of what to do as I had multiple conversations with my teacher about what I would have to do during the project. At first as I was sceptical about contacting and conversing with professionals and experts in the field of aerodynamics as I was not aware of how willing to help and understanding they would be. After many trial and error attempts to contact experts (as 60% of my contacts did not reply) I was contacted by Dr R who told me he was on a trip in America, he forwarded me onto his PHD students who were more than willing to help. After chatting over emails, we eventually decided on a time and date for the interview. I sent my questions ahead beforehand to allow time for preparation. This left more time to go in depth about any questions I had. This gave us more time to chat after we had introduced ourselves and talked a little bit about physics. This led on to me discovering that _ (one of the PHD students) had completed his masters project on a very similar topic to my project. We then used the remainder of the interview time to chat about his master's project as well as their PHD project about simplifying CFD (computational fluid dynamics) as many simulations can take from minutes to days to hours and their aim is to simplify the equations used to reduce the time taken to simulate.

With the knowledge that I gained, from both my own research and the interview, I had to simplify it down to an understandable level for my audience. Due to the fact that some of the information was above advanced higher level I frequently contacted the PHD students who said they would avidly help me throughout as much as possible to make sure the same assumptions could be made from my simplified explanations of the advanced physics and/or maths. After I had ensured my simplified explanations were correct, I handed out my survey to be completed. Any question that my audience had about the survey I answered as to allow them to complete my survey wholeheartedly. After I had completed my presentation, in which I frequently engaged with my audience by asking questions, relating to

survey results or answering questions, I handed out my survey once again to check how much information my audience retained from my presentation. I found that my audience were now able to answer every question in my survey which led to the conclusion that my presentation was informative and interesting.

I wasn't able to develop my interpersonal skills as much as I wanted to as I was unable to step out of my comfort zone due to the barrier of covid. This barrier prevented me from meeting my contacts in person which would have allowed me to step out of my comfort zone and develop my interpersonal skills further. If I had the chance in future to complete a similar project, I would try to arrange in person, face to face, meetings so I would be able to develop these skills.

Planning – time, resource and information management

(Think about your time management. How did you set targets, monitor/record progress, consider any probable barriers to achievement and take steps to minimise them?)

At first, I had planned to stick to my Gannt chart however I found myself relying on my weekly meetings with my teachers as well as reminders on my phone calendar which proved to be sufficient in keeping me on track for finishing my project. As I completed tasks, I would tick the reminder on my phone thereby removing it and this would then activate the next reminder notifying me of the next task to be completed and for when. By giving my allotted tasks extra time this gave me time to fix any problems that came up by using my contingency plans. The plan to use the Gannt chart did not work as I did not feel structuring my life around a chart was the best option for me and I didn't want to use something I didn't enjoy using.

Independent learning – autonomy and challenge in own learning

(Think about how you used your skills to make things happen, took the initiative to establish links with other learning environments/opportunities and looked for challenges rather than taking the easy option.)

I had to discover and approach my contacts myself without the aid of my teacher as well as conducting the interviews and maintaining further contact with them. I had to prepare questions to ask during the interview and also prepare questions for my survey. I maintained contact after the interview through email so I could continue to receive help from my contacts on any questions I had. For my survey, I had to gather the survey participants myself as well as create the survey and learn how to use survey monkey. I also made the decision to send out my survey once again after the presentation was done as to receive feedback on it and check whether or not my audience had retained the information. At the start of my project I thought that my project would mainly consist of knowledge surrounding physics however I quickly realised that I had to include my maths and graphic communication skills throughout to understand how some of the complex equations were derived and re arranged as well as understanding drawings and diagrams of Formula One cars. Although I withheld the complex equations from my presentation as I felt the level was too high for my audience this was still beneficial to my project as I was able to develop skills such as my analytical skills and problem-solving skills. The bulk of my information came from my interview with the three PHD students however I did carry out further research online, reading through journals and websites to further

my knowledge and cross reference any information that I had found. By working independently in gathering information, contacting professionals and presenting to an audience I feel this has greatly boosted my confidence in working independently as at the start of the project I had never done a large-scale project like this before. I was inexperienced and worried however now as I near the end of my project, I can see how valuable this project has been to me and how wonderful an experience it has been. From the results of my skills audit – which I completed three times throughout the course of the project - I can see that I was not able to develop my ability to find flaws in my reasoning as well as considering how a situation may have arisen and possible contributory factors.

Problem solving – creative approaches; critical thinking; logical approaches

(Think about your problem-solving skills. How did you generate and explore ideas, use logical and creative approaches, analyse source materials in order to support findings, reflect on problems and possible contributory factors and think critically about possible actions/changes?)

When generating ideas for my project the first thing that came to mind was nitrous engines. I had always been interested in racing however nitrous engines came to mind as I didn't know how they worked or any of the underlying knowledge behind them. However, this included a lot of chemistry which I had not done up until this year – crash higher – so I decided to step back and explore my other options. This is when I decided to focus on the aerodynamics of Formula One cars as I happened to see my dad watching it on the television. I had never really had an interest in Formula One beforehand however by asking my dad questions, he began to nurture my interest as I asked him questions. To gather information, I started off by gathering whatever surface information I could find from trustworthy websites such as Mclaren, Red Bull, Mercedes or information websites such as journals. I then used this surface information to identify key target areas that I would research and then went on to research them in greater detail by asking questions about them in my interview as well as browsing deeper into the web. For my interview I emailed my questions before hand, giving my contact enough time to prepare answers. This allowed us to have more time to go into further details about any topic area that I wanted to as well as extra time for any questions that I had. When creating my survey, I had to break down my questions so that they were simple and easy to interpret. As I had no idea of the level of knowledge possessed by my audience (that was the purpose of the survey). Throughout my project I had prepared contingencies for any part of it that could have gone wrong. For example, I had prepared primary contacts that I would first contact initially and then secondary contacts in case anything went wrong, or I did not receive enough information. I also ensured that my survey was completed on the spot when handed out as to receive the results instantly as well as leaving no room for error as they would not forget to complete it and I could explain anything they didn't understand while I was there. One thing that I did not plan for was how poor my time management skills would be. As I had to constantly be reminded by my phone calendar or teacher at weekly meetings to complete tasks that needed to be completed. However, this problem was easily overcome as I began to develop my time management skills throughout the project. The reason this problem arose in the first place was due to me not using my Gannt chart as I should have. I do not

regret this however as I feel that structuring my life around a chart is not how I wanted to plan my project.

Presentation skills

(Think about how you presented your findings. Evaluate your presentation method(s), choice of audience(s), layout, structure, degree of formality and choice of content. Did your presentation include information/ideas/reflections with supporting detail in a logical order and reach a reasoned conclusion?)

I chose to use Prezi for my presentation as it is easily accessed from anywhere due its accessibility through the internet. As well as the fact that it contained templates that I could use that were modern, colourful and contained animations. All of which helped to attract my audience's attention when presenting. I feel that my selection of audience was appropriate for my presentation as they were all interested in either Physics, Maths, Formula One or just the idea of my project as a whole. I started off my presentation by explaining some of the results from my survey and asking questions about them to engage my audience. I then lead on to explain the fundamentals of my project. I started off with aerodynamics which I then used to lead on to Bernoulli's principle and how it relates to drag. I then began to introduce the changes that had been made to the Formula One cars and explained the impact and effect of these changes on the cars. I introduced the idea of vortices and then went on to explain how they arose by using an analogy and props. I used a ball to represent a particle and then began to give examples of how it would gain rotational velocity allowing it to gain circular motion. I then introduced more particles and described how these vortices arose. I found that this worked as it helped my audience to visualise the process and I confirmed this through the nodding of my audiences heads and a discussion after the presentation. After explaining the basis of my research, I then began to lead to on to conclusions that would link into my aim. I then finished off with any extra information I wished to include such as information about the Formula One industry adapting and developing wind tunnels from the aeronautical industry to improve their understanding of aerodynamics as well as allowing the opportunity for any questions to be asked in which I was asked multiple questions which tested my knowledge however I answered them confidently.

Self evaluation – recognition of own skills development and future areas for development

(Think about how you have developed throughout your project. How did you deal with feedback, praise, setbacks and criticism and their impact on your own development of knowledge, skills and understanding? To what extent did you ask for feedback, learn from experiences and how will you use these to inform future progress?)

Over the duration of my project, I have developed both my skills as well as my character. This is due to the independent nature of the project which has helped to increase my confidence as well as my interpersonal skills as I had to contact and speak to professionals in my area of study solo. I learned that most of these professionals are more than willing to share and spread their knowledge which has filled me with confidence to approach situations such as these with a calmer

mindset as I know that I now have the ability to contact and speak to these professionals on my own. This confidence will most definitely assist me later in life especially in university where I will have to work with lecturers and PHD students who will most likely assist out with classes. I have developed the ability to deal with setbacks with a more positive mindset as I use these setbacks to develop myself further and push forward. Such as when I initially did not receive any replies form my contacts, I began to feel anxious and worried however as I received my first reply, I began to feel assured and more confident about getting replies as I began to receive more and more messages. This helped me to develop my problem-solving skills as I had to search for a solution which was to use my secondary contacts that I had set up as a contingency plan. I had planned to use my Gantt chart efficiently throughout my project however I quickly realised how lacking my time management skills were as I began to fall behind. However, my weekly meetings and phone calendar reminders were enough to keep my track during this project. I would have felt more confident throughout my whole project if I had stuck to my Gantt chart and my initial planning. I even feel this added pressure now as I evaluate myself in the last few days of my project under a strict time limit.

As a whole, my science baccalaureate experience has been one of the most enjoyable experiences of my senior year as it helps be to develop my physics, maths and graphical communication skills and core skills even further. Which will be a major asset to me in future including university and when I am working.

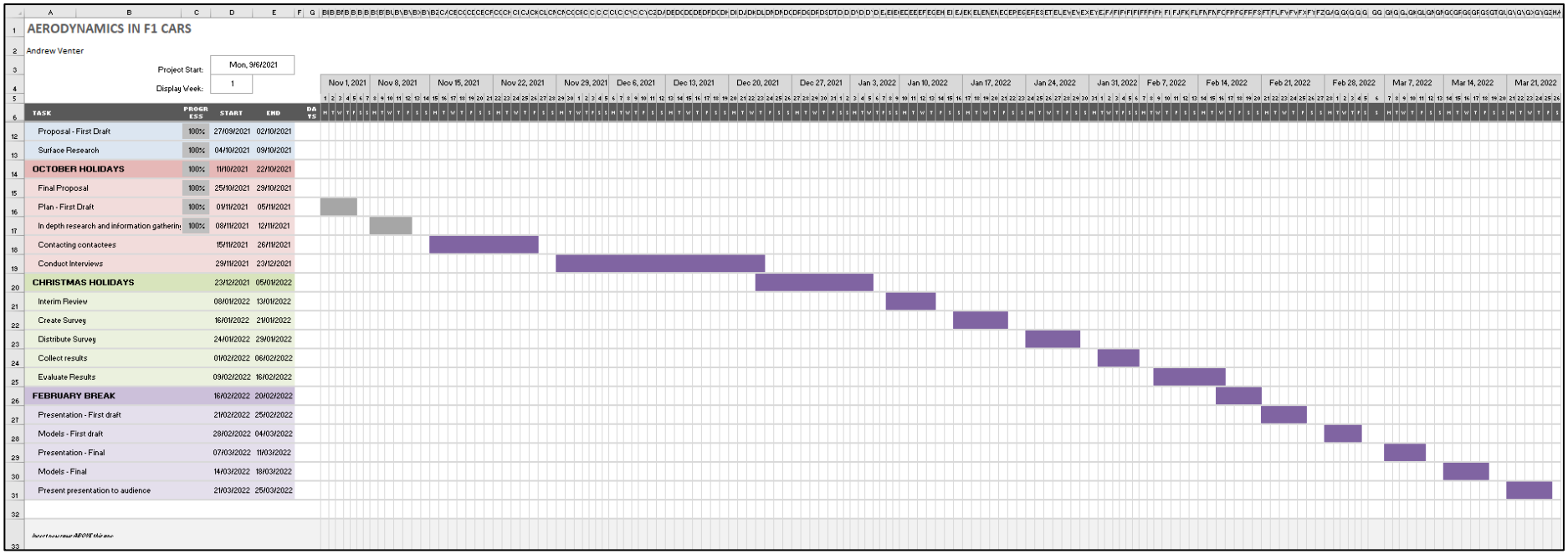
This section is not mandatory. It has been included to allow you the opportunity to undertake an overall reflection of your project.

Reflection on my experiences throughout this project *(eg things you feel you have achieved, things you have done that you feel particularly proud of, anything you would do differently were you to do something similar in future)*

After completing this project, I am very glad to say that I am filled with a sense of accomplishment. At the start of this project, I didn't know what direction it would take me in. But I am very glad that I chose to do this project as it has helped me to build skills and knowledge, both of which will be of vital importance later in my life. My presentation is probably the part I am most proud of I as I had never really presented anything of this scale. However, from the feedback I received it seems that I did a wonderful job which I am very happy with. If I were to do something similar in future I would most definitely include an experiment.

Skills that I have used in this project that I would like to develop further *(eg using skills in even more challenging situations, more working on your own, more team working)*

The skills that I would most like to develop are my interpersonal skills so that I would be able to work even better with others which is always helpful as well as my research and analytical skills and all of these will be able to help me later in life when working independently or in a team.



AERODYNAMICS IN F1 CARS

Andrew Venter

Project Start: Mon, 9/6/2021

Display Week: 1

TASK	PROGRESS	START	END	DAYS
Proposal - First Draft	100%	27/09/2021	02/10/2021	
Surface Research	100%	04/10/2021	09/10/2021	
OCTOBER HOLIDAYS	100%	11/10/2021	22/10/2021	
Final Proposal	100%	25/10/2021	29/10/2021	
Plan - First Draft	100%	01/11/2021	05/11/2021	
In depth research and information gatherin	100%	08/11/2021	12/11/2021	
Contacting contactees		15/11/2021	26/11/2021	
Conduct Interviews		29/11/2021	23/12/2021	
CHRISTMAS HOLIDAYS		23/12/2021	05/01/2022	
Interim Review		08/01/2022	13/01/2022	
Create Survey		16/01/2022	21/01/2022	
Distribute Survey		24/01/2022	29/01/2022	
Collect results		01/02/2022	06/02/2022	
Evaluate Results		09/02/2022	16/02/2022	
FEBRUARY BREAK		16/02/2022	20/02/2022	
Presentation - First draft		21/02/2022	25/02/2022	
Models - First draft		28/02/2022	04/03/2022	
Presentation - Final		07/03/2022	11/03/2022	
Models - Final		14/03/2022	18/03/2022	
Present presentation to audience		21/03/2022	25/03/2022	

Insert new row ABOVE this one

Science: Interdisciplinary Project

Assessor report

Candidate name __ _____

Candidate number _____

Centre ___ _____

Project proposal	Tick as appropriate
Grade C criteria	
The title and aims of the project.	✓
Clear aims and reasoned arguments to support the relevance and practicability of the project.	✓
Identification of opportunities for:	
own skills development	✓
collaborative working	✓
accessing less familiar learning environments	✓
application of science subject knowledge in a broad context	✓
use of knowledge and skills across different disciplines	✓
making connections between subject knowledge and the wider world	✓
Evidence of the ability to communicate clearly and concisely in advocating the proposal.	✓
Grade A criteria, includes all of above plus	
Well conceived proposal which sets creative and challenging goals which are at the same time realistic, achievable and practicable.	✓
Robust and carefully argued justification of the proposal.	✓
Substantial links and understanding of possible connections across disciplines contributing to the project.	✓
Comments The candidate has written a good proposal in terms of a challenging yet achievable project. They explained why they have chosen this topic due to their strengths in AH Physics and Maths. This candidate is intending in studying Engineering at University and this project has strong links to this. The candidate also links their Graphical Communication knowledge however this was not strongly used/applied during the project. The project will allow the candidate to gain a deeper understanding of Physics in terms of how increased tyre grip is achieved through aerodynamics creating more downforce and the candidate will apply Maths to understand the equations behind this.	

The outline of the project creates challenging goals in terms of researching and presenting information on a topic which the candidate is not knowledgeable on although it does relate to the candidates' academic strengths.

The candidate has made clear links to economic development, enterprise and sustainability in terms of improving the efficiency of F1 cars and thus reducing tyre wear and fuel consumption which results in the cars being more eco-friendly.

The candidate has identified the various opportunities for skills development and conducted a skills audit to reflect on where those skills are at the start of the project

Project plan	**Tick as appropriate**
Grade C criteria	
Development of clear project objectives in line with the project proposal.	✓
Relevant and detailed planning strands to enable the project to be implemented, monitored, presented and evaluated.	✓
Realistic timescales and achievable milestones for each stage of the project.	✓
Clear identification of resources needed, research methodologies to be used, opportunities for support and feedback.	✓
Grade A criteria, includes all of above plus	
Careful selection and effective use of research/investigation techniques.	✓
Anticipation of probable and possible factors which may impact on the project with realistic and well considered contingencies.	✓
Clear identification of dependencies or reliance on the success of other strands of work and of necessary adjustments to the plan.	✓
Outline the process for achieving own identified development needs.	✓

Comments

The candidate has broken down their project proposal into more specific tasks (page 4) and assigned realistic timescales within their GANTT chart which has been created with excellent detail. They have considered the holidays and their prelims in their GANTT chart which shows a good planning skills.

The candidate has considered some potential issues and planned contingencies accordingly. They have also considered the impact Covid-19 may have for their planned visit to the University of Glasgow and how to overcome this.

The candidate has given a list of dependencies (page 5 - 6) and this is also reflected in their GANTT chart. They show an awareness of which tasks rely on others i.e. creating their survey after completing their research and then evaluating the results before creating their presentation so it is at the correct level for the intended audience.

The candidate has outlined a good process for monitoring their development and areas for improvement by using their logbook, GANTT chart, weekly meetings and completing 3 skills audits at various times of the year.

While the candidate has not discussed in detail their research/investigation techniques they did complete this effectively by persevering and following up suggestions from one of the initial contacts and then interviewing several PhD students which proved vital to the project. The candidate does employ a good strategy of creating their survey to be distributed to the target audience and then use the feedback from this as part of their presentation.

Presentation of project findings/product	**Tick as appropriate**
Grade C criteria	
Evidence of effective and critical use of — resources, research methodologies, information and time management, prioritisation, problem solving approach to reach objectives, feedback, collaborative approaches, self-monitoring.	✓
Application of specialist and interdisciplinary subject knowledge to establish meaningful connections within the broad context.	✓
Clear presentation of main findings/outcomes.	✓
Grade A criteria, includes all of above plus	
Critical thinking, analysis and reflection used at key stages in the project to construct rigorous arguments, draw convincing, well supported conclusions, identify and resolve issues.	✓
Skilful and creative use of resources, including people, information and learning context to progress the project.	✓
Accurate and deepening of understanding through application of subject knowledge in the chosen context, with meaningful connections well established.	✓

Comments

The candidate delivered a highly successful presentation in terms of clearly explaining the aim and findings of their project. They discussed the findings of the survey within their presentation and gave background information relating to the project to fill in the gaps of the audiences' knowledge which was evident from analysis of the survey. The candidate took time and effort to select their audience and analysed feedback from questionnaires to ensure the presentation was at the correct level to be relevant and meaningful.

The Prezi presentation was skilfully created and was clearly effective in terms of engaging the audience and explaining the findings of their project. It was well structured, and the candidate did not use a script or notes as they had conducted the research effectively and prepared well for the presentation. The candidate's language was clear and at the appropriate level and their body language was confident yet friendly which showed good presentation skills. The candidate also made use of humour at times when asking for forgiveness if he mispronounced and of the names of Italian professionals that related to their research.

There was clear evidence of deepened subject knowledge when explaining vortices using a ball as a prop, and also when explaining how aerodynamics can lead to increased downforce due to the airflow being forced. The candidate also used analogies when explaining vortices and this proved effective as the audience responded positively to this. They displayed and explained some of the equations linked to this which was clearly beyond Advanced Higher Physics and Maths. There was some brief links to Design Technology and Graphical Communication when discussing the designs of rear wings, front wings and diffusers.

The candidate spoke with confidence and flowed as they were knowledgeable in the subject due to the amount of research completed.

Evaluation of project	**Tick as appropriate**
Grade C criteria	
A critical and justified evaluation of all stages of the project process — planning, implementation and findings/outcomes in terms of strengths, weaknesses and learning points.	✓
Effective use of chosen communication method(s).	✓
Grade A criteria, includes all of above plus	
Incisive, well balanced evaluation of the project outcome against project aims, supported convincingly by well selected evidence.	✓
Careful choice and skilful use of communication and presentation methods(s).	✓

Comments

The candidate learned to use the Prezi software and developed their ICT skills by doing so. They delivered their presentation well and communicated clearly throughout using their presentation as a guide i.e. they presented without using notes or a script. They also detail (page 19) their reasoning of why the used Prezi in terms of the animations and templates available to help engage and focus their audience.

The candidate discusses the successes of their project in terms of meeting the aims in terms of the various developments in F1 that have improved the aerodynamics and the Physics and Maths behind this. The explanation of the development of various designs

added to the car i.e. bargeboards, diffusers etc. and how this reduces turbulent air containing vortices is clear evidence of deepening subject knowledge via the research completed. They then explain the economic and environmental impact this has in terms of improving fuel efficiency, reducing tyre wear and being more eco-friendly (page 10).

The candidate also explains how the research and interviews they conducted were a success (page (11). They desired information was gathered, interviews ran smoothly and even remained in contact beyond the interviews.

There are some weaknesses discussed such as the lack of replies from the College, F1 companies or the issue of the Motorsport Industry Association not able to disclose details. They therefore targeted the backup contacts, as detailed within their contingencies (page 6), which proved more successful. They also detail how the impact of COVID-19 prevented them from visiting the University to access the library, interview professionals face to face or conduct experiments in their wind tunnel.

The candidate also reflects on the time and effort sent on selecting and organising the audience (pages 7 and 14) for their presentation and that using social media would have reduced this.

The candidate does not explain the lack of their report being produced however it had been discussed during several meetings that the presentation would be their product and the report would not be produced as all the summarised information was within their presentation and feedback from the surveys indicated this had been understood. In addition to this, the lack of time remaining once they had completed their presentation to produce the report and evaluations meant they had to prioritise. This should have been commented on as a weakness of the project however the candidate does evaluate in sufficient detail to meet the A criteria.

The candidate also reflects on their time management as a weakness as they did not manage to stick to their plan or GANTT chart. They did not anticipate the impact their extra-curricular commitment (the candidate swims competitively and trains/competes 5 days a week in addition to playing for a rugby team) would have on their project. They did adapt and made use of their phone calendar to help ensure they completed their project.

Self-evaluation of generic/cognitive skills development	**Tick as appropriate**
Grade C criteria	
A critical evaluation of own skills development against the list of specified generic/cognitive skills.	✓
A reasoned evaluation of own strengths and key goals for development in the specified list of generic/cognitive skills, which takes account of feedback sought and evidenced from others throughout the project.	✓
Grade A criteria, includes all of above plus	
Insightful, balanced, and well-structured self-evaluation of own development.	✓

Assertive and justified use of feedback from others in evaluation and identification of development areas.	✓

Comments

The candidate reflects on the various feedback they took on board at various stages of their project. The research seminar conducted by the school librarian allowed the candidate to employ various research methods effectively (page 14). This is evident by the cross-referencing of information and evaluating the reliability before finalising what was going to be in their presentation.

They also arranged to practise their presentation to a small number of staff so they could gather feedback which they used to then improve their presentation. This led to the candidate making use of some props to help visualise how particles act in vortices so the audience could understand. The candidate also altered some of the text within their presentation to ensure it could be easily read from the back of the classroom as suggested by a member of staff.

They discuss their deepened subject knowledge of Maths and Physics which was evident during the candidate's presentation in addition to their folio (pages 10, 13 – 14). This was possible due to the research and interview skills of the candidate developing during the project.

It is clear the candidate has developed their interview skills during this project as they had not experienced this before. Preparing and sending questions in advance to ensure they gather the required information was a good strategy. This also allowed the interview to flow smoothly and the candidate built a working relationship with one of the PhD students who remained in contact to check the content of the candidate's simplified research/presentation (page 16).

The self-evaluation is somewhat balanced in terms of strengths and weaknesses of skills. They do mention their indecisiveness as a weakness as this cost them valuable time to get started and when they did finalise a project they had to make an effort to catch up. Fortunately, their research skills and interviews allowed them to make up most of this time.

The candidate also identifies not sticking to their original plan and GANTT chart as a weakness and found themselves completing the majority of their work the day before the weekly meetings which proved stressful. The candidate does adapt and started to create reminders on their phone calendar to help improve their organisational skills. They show an excellent awareness of how not having weekly meetings with a mentor would result in the need for a more in depth approach to time management/planning (page 15).

The overall grade will be:

A indicative of a highly competent performance which meets the additional Grade A criteria and consistently demonstrates a high degree of autonomy, initiative and effective information management across the five pieces
B indicative of a competent Grade C performance across the five pieces, but with some aspects of work meeting the criteria for highly competent performance (as outlined by the Grade A criteria)
C indicative of a competent performance across the five pieces, with all aspects of the work meeting the criteria identified for Grade C performance

Overall grade awarded	**(A) B C Unsuccessful**
Additional comments/overview A good project with very strong evaluations. The candidate has developed a range of skills during the completion of their project and has applied their Physics and Maths well to gain a deeper understanding of how this applies to aerodynamics.	

Assessor signature _____ **Date**_____

Co-assessor signature _____ **Date** _____

External verifier signature ____ _____**Date** _22/3/22____