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Engineering Skills Technical Report

Engineering Skills (ACHA4022A)

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1.Introduction

This report presents several core fields of engineering practice that are essential for engineering students and aspiring industry professionals. It starts by looking at engineering environments and the health and safety within and therefore the use of risk assessments and relevant legislation to ensure a safe workplace and procedures. Furthermore, the report explores security threats impacting modern automotive systems and therefore evaluating these threats using a security risk matrix.

The role of engineers in society, sustainability and ethical practices and focusing on professional conduct is outlined. In addition, this report examines the application of methods engineers use when dealing with challenges during design and development. Lastly, the importance of efficient teamwork and how it can be improved, comparing it with researched team structures.

2. Health & Safety

2.1 Introduction to Workshop Safety

Safety in an engineering workplace is essential especially when operating machines such as lathes and milling machines. Both machines consist of moving rotational components, sharp cutting tools and high-speed material removal, therefore all users must adhere to health and safety procedures. Appropriate personal protective equipment (PPE) is always a requirement, these include for example, steel toe cap footwear, protective eyewear and workshop coats. Using PPE reduces risk of eye injuries from metal swarf, heavy impact injuries from dropped components, protecting skin from foreign contaminants and numerous other risks (Health and Safety Executive, 1999).

2.2 Relevant Legislation and Guidance

Activities carried out in the workshop and other engineering facilities in the UK are overseen by several pieces of UK legislation. The Health and Safety at Work Act 1974 obligates employers and educational institutions to guarantee workshop equipment is up to safety standards and that students are protected from hazards (UK Government, 1974). The Provision and Use of Work Equipment Regulations (PUWER) 1998 ensures equipment such as lathes and milling machines are to be properly maintained and only used by trained personnel and fitted with the appropriate guards to reduce risk (HSE, 2013). The HSE provide guidance on hazards, risks of entanglement and the importance of guarding, particularly when using rotational equipment (Health and safety Executive, 2024).

2.3 Hazards Associated with Lathes and Milling Machines

Milling Machines and Lathes both present risks which are similar:

Lathe Hazards

- Entanglement with rotating chuck
- Metal Swarf ejected at high speed
- Cuts from sharp cutting tools

Milling Machine

- Contact with the rotating cutter
- Flying debris from cutting process
- Sharp edges on machined parts

Measures to keep engineers and students safe include, tying back long hair, sleeves must be secure, guards in place and emergency stop buttons. Behaviour around the machines must also be monitored, supervision and proper training following standard operating procedures reduce risk (Health and safety Executive, 2024)

2.4 Risk Assessment

Risk Assessments identify hazards in a workplace and evaluates how dangerous each one is. Hazards are assessed by their likelihood and evaluated by how much harm they can cause, which then determine the overall risk level.

Table 1. Risk Assessment to show hazards in workplace/academia and their controls.

Hazard	Likelihood	Severity	Risk Level	Controls
Metal swarf striking eyes	Medium	High	High	Protective eye wear; machine guards; correct cutting speeds
Entanglement in rotating chuck/cutter	Low	Very High	High	Tie back hair; secure coat; maintain distance
Foot injuries from dropped components	Low	Medium	Low	Steel toe cap footwear
Noise exposure from machinery	Medium	Medium	Medium	hearing protection; limit exposure; maintain machinery
Burns from hot swarf	Medium	Medium	Medium	Allow metal to cool; use gloves when appropriate
Workpiece becoming loose and ejected	Low	Very High	High	Tighten chuck properly; secure workpiece; supervision and correct fixturing
Incorrect or delayed use of emergency stop	Low	High	Medium	Training; clear signage; demonstrations
Distraction or loss of concentration	Medium	High	High	No Phones; maintain focus; training and supervision

3.Security Risk Matrix

3.1 Introduction

Software, wireless communication and electronic control systems have been implemented on modern vehicles which are now becoming increasingly dependent on them. Consequently, they now have increased vulnerability to cyber-attacks. Modern vehicles can be affected through telematics units, infotainment systems, wireless key fobs and in certain instances vehicle to infrastructure communications (Ignacio, Watson and Angelopoulou, 2023). Cyber attacks are now an engineering concern, it can result in failures leading to loss of control in vehicles, privacy breaches or even physical harm to passengers.

3.2 Common Automotive Cybersecurity Threats

Below are several well documented and realistic threats from cyber-attacks on automotive connected vehicles.

- Keyless entry attacks: extending the signal from the key fob which then unlocks the vehicles enabling the attackers to start and drive off (Valasek, 2015).
- CAN-bus injection attacks: Research has shown that the vehicles internal controller area network (CAN) can be injected with malicious messages, therefore allowing attackers to control steering input, braking or acceleration (Koscher et al., 2010).
- GPS and sensor spoofing: ADAS or autonomous systems can be tricked using false signals. Lidar, radar and cameras on vehicles can be modified through signals sent from attackers (Petit and Shladover, 2014).
- Telematics and infotainment exploitation: Cellular modules, Wi-Fi, Bluetooth and infotainment firmware can be used to remote wireless hacks (Valasek, 2015).
- Malicious firmware updates: Over the air updates which can have weak security can allow the installation of modified or malicious firmware (Checkoway et al., 2011).

3.3 Security Risk Matrix

This Security Risk Matrix allows engineers to evaluate each threat by its likelihood and impact; this means they can prioritize the most dangerous vulnerabilities.

Table 2: Security Risk Matrix for Common Automotive Cybersecurity Threats

Likelihood ↓ / Impact →	Low Impact	Medium Impact	High Impact
High Likelihood	Medium Risk	High Risk – Keyless relay attack	High Risk
Medium Likelihood	Low Risk	Medium Risk – GPS spoofing	High Risk – CAN-bus injection
Low Likelihood	Low Risk	Low Risk	Medium Risk – Telematics hacking / Malicious firmware

3.4 Engineering Response

The Keyless relay attack and the CAN bus injection require strong engineering controls being the highest risk. The use of Ultra-Wideband (UWB) key systems can reduce attacks from keyless relay attacks; they measure the actual distance between the vehicle and key. Disabling the key when it is not in motion prevents attackers for relaying the signal (Valasek, 2015). Message authentication can address the problems of CAN-bus injection, segmentation of safety networks and in vehicle intrusion systems that can monitor abnormal patterns (Koscher et al., 2010; Checkoway et al., 2011). Sensor fusion and GNSS signals can mitigate the use of sensor spoofing (Petit and Shladover, 2014). Engineers can implement a safe boot mode for software based threats which is a cryptographically signed firmware therefore preventing the download of unauthorized updates.

4. Engineers Role in Society

4.1 Ethics and Professional Responsibilities

Public safety is of the upmost importance; engineers play a crucial role in this as their decisions directly influence this; they also influence sectors such as environmental sustainability and technological development. The Engineering Council emphasize all engineers must act with integrity, accuracy and responsibility; this follows established standards to protect the public (Harris, Pritchard and Rabins, 2018). Ensuring that their work does not endanger people or the environment, communication openly and honestly and avoiding conflicts.

4.2 Sustainability and Social Impact

The Engineering Council guidance explains that engineers should “use resources efficiently and effectively” and “take a leadership role on sustainability” (Engineering Council, 2021). Engineering influences society and therefore they must integrate sustainability into their work. Throughout motorsport engineering, engineers must prioritise safety, technological improvements and material efficiency. Advances made in motorsport such as lightweight composites, energy recovery systems and aerodynamics are often transferred to everyday cars thus contributing to wider engineering. Long term social and environmental consequences must be considered when developing an engineering solution, engineers should show initiative in this role (The Royal Academy of Engineering, 2005)

4.3 Professional Conduct in Motorsport Engineering

Motorsport demands strict professional standards due to the high-risk environment and nature of the sport. Vehicles must meet safety requirements, failure can lead to severe consequences to spectators, teams and most importantly the driver. A clear set of expectations for safety and responsible technological development has been implemented by the FIA known as the FIA code of ethics (FIA, 2020). Motorsport Engineers must therefore balance performance optimisation with safety critical design, complying with the regulations and accurate data handling. This reflects on broader scale the responsibility an engineer must have, to ensure act in public interest and ensure trust in their profession from consistent ethical standards.

5.Problem Solving

Engineering relies on structured solving techniques to manage uncertainty, diagnose issues and guide decisions made throughout the product development process. Creating a new design can lead to engineering issues, conflicting requirements and performance limitations. This chapter aims to outline the main problem-solving methods engineers use in projects. To identify the root causes of issues, develop suitable solutions and that the products meet safety, quality and performance requirements.

The Technological Method of Problem Solving

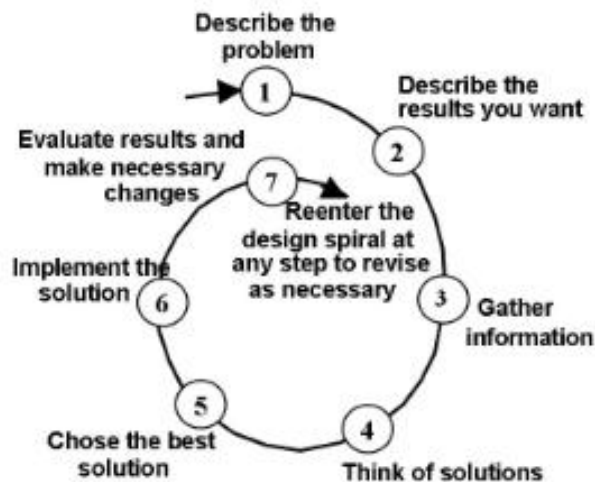


Figure 1 Technological Method of Problem Solving (Teach Engineering, 2013)

Engineers often follow a systematic approach when it comes to solving problems, systematic approaches are efficient and often provide logical flows of knowledge and progress (Teach Engineering, 2013). The flow diagram shown below represents the technological methods of problem solving, a structured iterative approach used in engineering which addresses issues that can arise during product development. The model breaks down solving into a clear set of steps, starting with defining the problem and the results wanted, followed by gathering information, solutions and selecting the most appropriate one. The method moves to implementation and evaluation, where the solution can be tested and refined as needed. The spiral design allows engineers to revisit earlier stages whenever new results, information or constraints emerge (Teach Engineering, 2013). Using a method like this ensures that decisions are made systematically, helping to reduce errors and support engineers in producing products.

The Technological Method of Problem Solving can be applied to vehicle development, for example. A prototype car might show excessive vibration during testing therefore engineers would use the flow diagram to investigate the source. The problem is defined, the required ride quality is set and information such as suspension geometry, NVH (Noise Vibration Harshness) data and damper settings are gathered, after that the most suitable option is implemented. The cycle will repeat if the issue is still not resolved from retesting the vehicle.

6. Team Structure

6.1 Personal Review and Reflection

During the soapbox project in my previous year, I worked in a team consisting of 4 other students, where each student was assigned a different responsibility such as design, costing, materials research and presentation work. Working as a team of this size was beneficial because we were able to split up the tasks between members, therefore reducing the workload and concentrating on individual targets set. I personally focused on the technical elements of design and assisted other members with analysing engineering requirements for chassis, braking and steering layout. In general, the communication within the group was at a good standard, as we had progress meetings in person and online. This ensured that our design decisions aligned with project objectives and were not off track. However, I noticed that whenever multiple suggestions were made at once it made it hard for us to decide on which method to use as different group members had different views on why a method would be better, this slowed down our progress. This experience overall has taught me why leadership is crucial when working as part of an engineering team.

6.2 Team Structure Used

Our group generally operated with no main team leader, a flat team structure (Motion, 2023). Where everyone had equal input and decisions were made collectively instead of through a single team leader. I believe that because of this structure it made it easier for our team members to communicate openly with each other, this was very useful during the early design stages of our soapbox. The flexibility of this structure meant members could assist other members and even when needed to change roles. However, as I mentioned previously, our lack of team leader meant when disagreements occurred it took longer than necessary to settle on an option, which effected our pace. The absence of a leader sometimes made it difficult to maintain momentum when options differed.

6.3 Alternative Team structure

A hierarchal team structure could of improved our workflow, even know they are most used in much larger groups (NI business, 2015) having one main leader who could oversee all areas of the project would be beneficial because this structure helps streamline decision making where the leader can evaluate suggestions, resolve conflicts and choose the most appropriate solution.

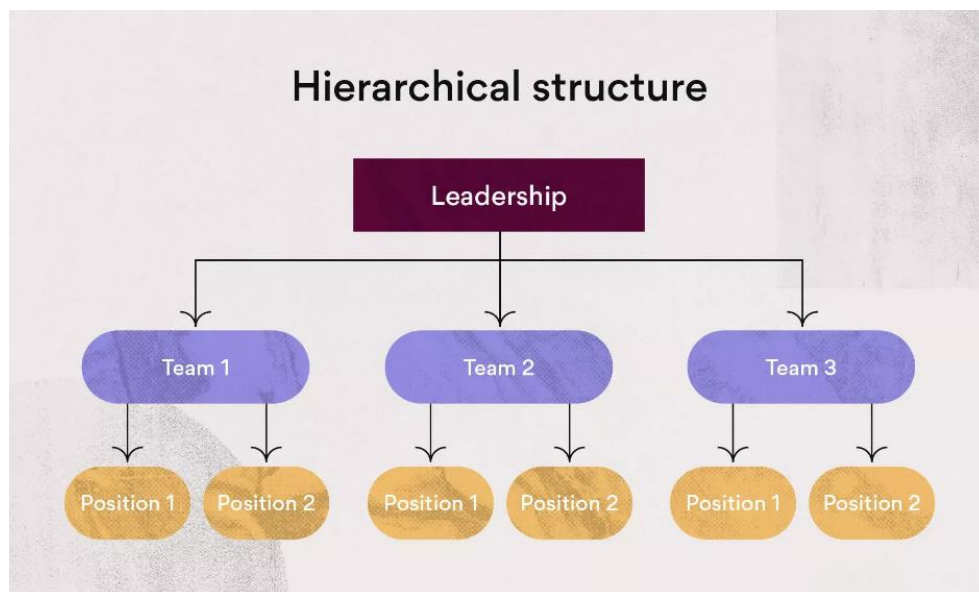


Figure 2 to show Hierarchical structure (Team Asana, 2021)

7. Conclusion

The fundamental engineering topics covered in this paper are crucial for students and aspiring professionals. Essential components include health and safety in engineering settings, where risk assessments, laws and rules all collaborate to guarantee that workshops are operating at the highest levels and that all equipment and procedures are used safely and responsibly in accordance with regulations.

Modern cars' growing reliance on electronic control and connectivity exposes us to new cybersecurity risks. Engineers can efficiently prioritise the vulnerabilities by using tools such as the security risk matrix, highlighting the wider social responsibilities that engineers have. Engineering decisions are supported by professionalism, sustainability and ethical behaviour. Safety is paramount in industries like motorsports.

Problem-solving techniques include the technological method that can be used by engineers in order to handle complex designs, make informed judgments, and solve problems.

Finally, working in teams is a major part of engineering practice. Analysis of past experience reveals how the type of team organization affects decision-making communication and workflow: the teams with flat organizational structures can be more flexible and the decision-making and advancement can be guided by strong leadership.

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