Abstract

This report contains details relating to the compulsory industrial training that I have carried out as required for the Engineering degree at the University of New South Wales. It is written in the format set out by the School of Mechanical and Manufacturing Engineering. I have completed a total of 95 days of industrial training over my two placements.

Contents

1 Introduction

1.1 Royal Children's Hospital

I completed my first industrial training internship with the Biomedical Engineering department at the Royal Childrens Hospital (RCH) in Melbourne. RCH is one of the leading pediatric hospitals in Australia and have been in operation for over 140 years. The current hospital building was opened in 2011 and on top of its primary purpose of providing care for childrens it also includes clinical, research and educational facilities.

The Biomedical Engineering department at RCH is responsible for delivering a wide range of technical and administrative services that are related to the ongoing support of medical and laboratory equipment. Some of these services include routine maintenance, safety and performance testing, acceptance testing, electrical area testing, acquisition and replacement advice etc.

I was working as an intern in a team of 10 engineers and technologists in the department. My manager was Inna Velasquez. As an engineering intern at the Biomed department I had a wide variety of roles and responsibilities. Some of these included the preventative & corrective maintenance and acceptance testing of medical assets whilst adhering to AS 3551 & AS 3760 engineering standards. Depending on the medical device and the needs of the hospital different kinds of work was carried out, ranging from simple battery replacements to re-calibration of the sensors, decommissioning of aged equipment and Electrical Safety Testing (EST).

As there was a constant flux of medical devices coming in and out of the hospital, I had to ensure that the correct procedure was undertaken when working with the different kinds of medical devices. During the course of my work I also liaised with other hospital staff and representatives from medical companies in regards to the medical assets that the department was looking after.

I worked at RCH from 12 December 2014 to 27 February 2015 for a total of 51 days.

1.2 Paul Scherrer Institute

My second placement was at Paul Scherrer Institute (PSI) which is located just outside of Zurich, Switzerland. PSI is a multi-disciplinary research institute center for natural sciences and technology and is the largest of its kind in Switzerland. It is currently carrying out cutting-edge research in the fields of matter and materials, energy and environment and human health.

PSI offers access to their large research facilities via a user service to researchers from universities, other research centers and industries from around the world. Some of these facilities include several particle accelerators such as the SINQ neutron source, SμS muon source and the Swiss Light Source (SLS) which is widely regarded as one of the worlds best in regards to electron beam brilliance and stability. A new X-ray free-electron laser called the SwissFEL is currently being constructed at PSI and is set to begin operation in 2016.

As a mechanical engineering trainee, I worked in the Department of General Energy under the supervision of PhD student, Dominic Gschwend. I was tasked to assist Dominic with his current work on biofuels. A thermodynamic model of an Internal Combustion Engine (ICE) was built in Simulink to test the influence of different fuel properties. As there was already a model of a gasoline engine, my work involved the conversion of this engine from spark ignition to compression ignition (Diesel).

I carried out a literature review on the different approaches that have been taken when modelling this engine and implemented it into the model. The modelling approach involved the breakdown of the problem in to smaller little problems which then made it easy to apply the governing equations into each part. This work enabled me to implement what I learned during my ICE course in my university degree, in particular the thermodynamic cycles that are present in a diesel engine. In addition I was also able to refine my literature review skills.

I worked at PSI from 1 July till 31 August 2015 for a total of 44 working days.

2 Engineers Australia Competencies

2.1 Knowledge and Skill Base

1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline

My work at PSI required me to apply numerous engineering principles and knowledge in order to solve the problems at hand. The applications of these engineering skills were crucial in order for me to fully understand and appreciate the work I was carrying out.

Since my primary role was to convert the gasoline model of the ICE into a diesel one, I had to ensure that I was familiar with the underlying thermodynamic principles of this engine. I had completed the Automobile Engine Technology course (MECH9761) at university and since this work was quite similar to what was taught in that course, it was easy for me to understand and apply the correct engineering principles. Apart from the basic knowledge of thermodynamics, I also had to research and understand the scientific and mathematical principles that try and explain the inner workings of a diesel engine. I broke my work down into sub-sections for easier analysis. For the modelling aspect of the diesel engine these included the intake and compression, fuel injection, spray formation, droplet evaporation, combustion and heat release rate. Each of these sub-sections had their own specific properties and group of governing equations that needed to be implemented to the model. Some of these equations can be seen below[1].

Spray Cone angle of the diesel spray:

$$\phi = 83.5 \cdot \left(\frac{L}{D}\right)^{-0.22} \cdot \left(\frac{D}{D_o}\right)^{0.15} \cdot \left(\frac{\rho_{gas}}{\rho_{fuel}}\right)^{0.26}$$

Break-up length of the injected spray:

$$L_b = 7 \cdot D \cdot \left(1 + 0.4\frac{r}{D}\right) \cdot \left(\frac{p_{gas}}{\rho_f u^2}\right)^{0.05} \cdot \left(\frac{L}{D}\right)^{0.13} \cdot \left(\frac{\rho_{fuel}}{\rho_{gas}}\right)$$

Break-up time of the spray:

$$t_b = 28.65 \cdot \frac{\rho_f d_{nozzle}}{(\rho_{air}\Delta p)^{\frac{1}{2}}}$$

The aim of this model was to obtain the relationship between the properties of the fuel being injected and the resulting spray formation/droplet sizes inside

[1] Hiroyasu, Hiro, and Masataka Arai. Structures of fuel sprays in diesel engines. No. 900475. SAE Technical Paper, 1990

the diesel engine. However most of the literature only explored the influence of the physical injector geometry on the fuel spray and not the properties of the fuel itself.

Multiple different modelling approached were taken, utilizing equations from a variety of different literature to obtain the desired output. For example when evaluating the size of the droplet diameters inside the diesel engine multiple different equations were provided from literature. Some of them included additional fuel parameters which was quite desirable in this model. Since these results needed to be validated, it turned out that the majority of these equations did not produce droplet diameters that matched experimental data from other sources. It was decided then that it was more important for the model to re-create the conditions that matched the most with real-world results. Thus only the equations that produced these outputs were utilized.

2.2 Engineering Application Ability

2.2 Fluent application of engineering techniques, tools and resources

During my time at RCH, I had to carry out preventative maintenance on a wide variety of medical devices. Each device had a different set of instructions in regards to the maintenance and calibration processes. As a result I was constantly determining the correct course of action that needed to be taken when carrying out my work. Selecting and applying the correct material and device component to be utilized was only one part of my role in preventative maintenance. I utilized the local asset management system to access and update the record of any device I was working on. This way it was easy to keep track of the assets the department was looking after.

The use of this asset management system also made it possible to create a schedule for the next batch of upgrades that were required for the medical device. With constant developments in medical technology, it was necessary to keep up to date with the market. I was given the task of investigating the possible obsolescence of an optical surgical system that the ophthalmology department was working with. I contacted the local Australian representative of the company in order to confirm and establish when the surgical system would be listed as obsolete. Even though a formal notice was not issued by the company, I was informed that there was a high likelihood that it might happen before the end of the year. Before reporting back, I researched and provided a list of possible replacements that were currently in the market so that the ophthalmology department could prepare and carry out their own feasibility study for a replacement.

Electrical safety in hospitals is of immense importance as patients may be undergoing diagnostic or treatment procedures where the insulating effect of dry skin is reduced or in some cases non-existent. Electrical systems and their components are encased in non-conducting insulation which ensures that the current only flows through the intended pathway. However during the lifetime of a medical device the insulation may deteriorate and the current may leak through to the operator.

Before any medical device was sent from the department to the hospital wards, I carried out an Electrical Safety Test (EST) on the device to ensure that any leakage current stayed within the safe working limits and that the protective earthing was working as intended. In the event that it fell outside the safe working limits, I usually took the device apart and checked the interior cabling and housing to ensure that there were no obvious and simple reasons for the current to leak out.

The literature review I carried out for the modelling of the diesel engine during my work at PSI provided me with a wide variety of information describing the inner workings of the engine. This was all based on scientific principles and expressed in the form of mathematical equations. I selected and applied the most relevant equations for the model based on the primary needs and goals of the model.

The primary goal was to recreate the conditions inside the engine and validate them with real-world experimental results. However there were many assumptions that needed to be taken when modelling this engine. For example, the computational time needed to be taken into consideration when creating the model. In addition it was also necessary to simplify the model by increasing the number of controls, primarily when deciding the physical geometries of the injector and cylinder size.

Whenever it was available I compared the data obtained from the model to similar actual experimental data to assess the suitability of the modelling approach. This way it was easy to identify potential sources of errors and discrepancies and I always looked to either remove or minimize these errors. The majority of the time, it was a case of applying a different equation if one did not work and then comparing the results again.

2.3 Professional and Personal Attribues

3.1 Ethical conduct and professional accountability

As an intern working at both of my placements, I have always committed to the values and principles that define an engineer in accordance to the Engineers Australia - Code of Ethics. A lot of my personal values align very closely to the ones that are defined by Engineers Australia so during my placements, I had the opportunity to apply them in a professional environment.

I am always honest with everyone I work with and always act on the basis of a well-informed conscience. As an engineer, I am always looking to maintain and develop my skills whilst upholding the reputation of the engineering practice. I am confident in my skills however I am not afraid to ask questions when required. The work environment at RCH included a lot of engineers with a wealth of experience and I always ensured that I was learning something new from them each day at work, either though observation or through some form of interaction. This was crucial for my learning as I picked up a lot of knowledge that enabled me to work more effectively and develop as an engineer. Working at a public institution like a childrens hospital meant that I was always interacting with and in the presence of the general public. Thus it was imperative that I set myself as a professional and model engineer.

I am a big advocate of a sustainable future so regardless of where I work, I am always engaging with not only with the community but with numerous stakeholders in regards to balance the needs of the present with the needs of future generations. In addition the principles of intellectual property rights and protection are quite clear to me as my second placement involved working with an engineering model that is currently only accessible to those with required clearance.

3.2 Effective oral and written communication in professional and lay domains

Both of my internships that I carried out required me to have a high level of communication and interpersonal skills. For example, whilst at RCH I was constantly in contact with a wide variety of stakeholders both in and out of the hospital. A large number of hospital staff would contact the department, either through the phone, email or in person with their queries. In addition representatives from medical companies would usually be coming in as well. As an intern, I was given the opportunity to interact with numerous staff members and assist them when required. I learned how to deal with a wide variety of people and address each situation in a manner suited to that particular scenario. For example, talking to a fellow engineer or a medical device representative would be very different to a nurse since their technical backgrounds are vastly different.

Similarly working at PSI in Switzerland was also a very refreshing challenge as even though English was widely spoken at the workplace, the workplace culture and social behavior there is different to what I've experienced in Australia.

Due to PSI being a research facility, there were people from a wide variety of backgrounds and cultures working around me. I incorporated a higher level of body language and non-verbal communication processes into my interactions with other people which enabled me to express my ideas more easily.

Staff meetings provided me with the chance to listen and comprehend the viewpoints of others. I also used this opportunity to raise any concerns I had or ask the group for their advice on certain matters.

The work I carried out at PSI required me to constantly work with scientific documents and literature. During the weekly meetings with my department, I was required to present a report on the work I carried out over the past week. In addition, during the last week of work I also gave a presentation of the work I had carried out over my placement. Most of the audience had either an engineering or a scientific background but were not as familiar with the mechanical engineering aspect of my work. I adjusted my presentation to the wider audience by simplifying it into basic scientific processes and as a result I was still able to provide a technical presentation that clearly demonstrated my work.

3.4 Professional use and management of information

The need to find and access relevant published works and data was a core part of my work during my placement at PSI. Since my role had a strong research and development focus, I had to access local and international databases in order to find the relevant publications. On top of the access I have with UNSW library, I also utilized resources like international Web of Science page and Lib4RI which is the combined online library of the local research institutes here in Switzerland. These resources greatly helped me with my literature review and provided me with plenty of information to dig through for my work.

I always utilized peer reviewed articles and journals whenever I had to locate any information. This way it was easier to evaluate the authenticity of the information presented. However a more rigorous approach had to be taken when evaluating the accuracy and reliability of any of the publications. This was generally based not only on the article, authors and journals involved but also on the amount of similar research being carried out in this field. As I learned with my work, the reliability of certain modelling equations can only be validated when numerous real world experiments provide similar results.

Document identification, tracking and control procedures are also very important parts of any engineering work. At RCH, I used the local asset management software to keep track of all the medical devices that were currently in use in the hospital. Through the use of this tracking and identification software, I could easily bring up the history of any individual medical device. Thus when I carried out preventative and corrective maintenance, it was possible for me to see what kind of work was carried out previously and make any further adjustments if required.

3 Reflection & Conclusion

Working at both RCH and PSI was a great experience. The different variety of work at the hospital and at the research institute provided me with a great deal of knowledge and skills about how the information learnt at University transfers over to the workplace. In addition another major aspect of my industrial training was teamwork & communication. After working at these two different environments I am able to appreciate how engineers work together to achieve a common goal. I learnt a lot about professional communication, how to discuss as a team and compromise when conflicting ideas arise and finally how to arrive at a decision as a team.

4 Engineers Australia Indicators of Attainment

Table 1 Knowledge and Skill Base: Elements and Indicators

ELEMENT OF COMPETENCY	INDICATORS OF ATTAINMENT
1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline.	**a) Engages** with the engineering discipline at a phenomenological level, applying sciences and engineering fundamentals to systematic investigation, interpretation, analysis and innovative solution of *complex* problems and broader aspects of engineering practice.
1.2 Conceptual understanding of the, mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline.	**a) Develops and fluently applies** relevant investigation analysis, interpretation, assessment, characterisation, prediction, evaluation, modelling, decision making, measurement, evaluation, knowledge management and communication tools and techniques pertinent to the engineering discipline.
1.3 In depth understanding of specialist bodies of knowledge within the engineering discipline.	**a) Proficiently applies** advanced technical knowledge and skills in at least one specialist practice domain of the engineering discipline.
1.4 Discernment of knowledge development and research directions within the engineering discipline.	**a) Identifies and critically appraises** current developments, advanced technologies, emerging issues and interdisciplinary linkages in at least one specialist practice domain of the engineering discipline. **b) Interprets and applies** selected research literature to inform engineering application in at least one specialist domain of the engineering discipline.
1.5 Knowledge of contextual factors impacting the engineering discipline.	**a) Identifies and understands** the interactions between engineering systems and people in the social, cultural, environmental, commercial, legal and political contexts in which they operate, including both the positive role of engineering in sustainable development and the potentially adverse impacts of engineering activity in the engineering discipline. **b) Is aware of** the founding principles of human factors relevant to the engineering discipline. **c) Is aware of** the fundamentals of business and enterprise management. **d) Identifies** the structure, roles and capabilities of the engineering workforce. **e) Appreciates** the issues associated with international engineering practice and global operating contexts.
1.6 Understanding of the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the engineering discipline.	**a) Applies** systematic principles of engineering design relevant to the engineering discipline. **b) Appreciates** the basis and relevance of standards and codes of practice, as well as legislative and statutory requirements applicable to the engineering discipline. **c) Appreciates** the principles of safety engineering, risk management and the health and safety responsibilities of the professional engineer, including legislative requirements applicable to the engineering discipline. **d) Appreciates** the social, environmental and economic principles of sustainable engineering practice. **e) Understands** the fundamental principles of engineering project management as a basis for planning, organising and managing resources. **f) Appreciates** the formal structures and methodologies of systems engineering as a holistic basis for managing complexity and sustainability in engineering practice.

Notes:

1. *'engineering discipline' means the broad branch of engineering (civil, electrical, mechanical, etc.) as typically represented by the Engineers Australia Colleges.*
2. *'specialist practice domain' means the specific area of knowledge and practice within an engineering discipline, such as geotechnics, power systems, manufacturing, etc.*

<u>Table 2</u> Engineering Application Ability: Elements and Indicators

ELEMENT OF COMPETENCY	INDICATORS OF ATTAINMENT
2.1 Application of established engineering methods to *complex* engineering problem solving.	**a) Identifies, discerns and characterises** salient issues, **determines and analyses** causes and effects, **justifies and applies** appropriate simplifying assumptions, **predicts** performance and behaviour, **synthesises** solution strategies and **develops** substantiated conclusions. **b) Ensures** that all aspects of an engineering activity are soundly based on fundamental principles - by diagnosing, and taking appropriate action with data, calculations, results, proposals, processes, practices, and documented information that may be ill-founded, illogical, erroneous, unreliable or unrealistic. **c) Competently addresses** engineering problems involving uncertainty, ambiguity, imprecise information and wide-ranging and sometimes conflicting technical and non-technical factors. **d) Partitions** problems, processes or systems into manageable elements for the purposes of analysis, modelling or design and then **re-combines** to form a whole, with the integrity and performance of the overall system as the paramount consideration. **e) Conceptualises** alternative engineering approaches and **evaluates** potential outcomes against appropriate criteria to justify an optimal solution choice. **f) Critically reviews and applies** relevant standards and codes of practice underpinning the engineering discipline and nominated specialisations. **g) Identifies, quantifies, mitigates and manages** technical, health, environmental, safety and other contextual risks associated with engineering application in the designated engineering discipline. **h) Interprets and ensures** compliance with relevant legislative and statutory requirements applicable to the engineering discipline. **i) Investigates** complex problems using research-based knowledge and research methods.
2.2 Fluent application of engineering techniques, tools and resources.	**a) Proficiently identifies, selects and applies** the materials, components, devices, systems, processes, resources, plant and equipment relevant to the engineering discipline. **b) Constructs or selects and applies** from a qualitative description of a phenomenon, process, system, component or device a mathematical, physical or computational model based on fundamental scientific principles and justifiable simplifying assumptions. **c) Determines** properties, performance, safe working limits, failure modes, and other inherent parameters of materials, components and systems relevant to the engineering discipline. **d) Applies** a wide range of engineering tools for analysis, simulation, visualisation, synthesis and design, including assessing the accuracy and limitations of such tools, and validation of their results. **e) Applies** formal systems engineering methods to address the planning and execution of complex, problem solving and engineering projects. **f) Designs and conducts** experiments, **analyses and interprets** result data and **formulates** reliable conclusions. **g) Analyses** sources of error in applied models and experiments; eliminates, **minimises or compensates** for such errors; **quantifies** significance of errors to any conclusions drawn. **h) Safely applies** laboratory, test and experimental procedures appropriate to the engineering discipline. **i) Understands** the need for systematic management of the acquisition, commissioning, operation, upgrade, monitoring and maintenance of engineering plant, facilities, equipment and systems. **j) Understands** the role of quality management systems, tools and processes within a culture of continuous improvement.

Table 3 Professional and Personal Attributes: Elements and Indicators

ELEMENT OF COMPETENCY	INDICATORS OF ATTAINMENT
3.1 Ethical conduct and professional accountability	**a) Demonstrates** commitment to uphold the Engineers Australia - Code of Ethics, and established norms of professional conduct pertinent to the engineering discipline. **b) Understands** the need for 'due-diligence' in certification, compliance and risk management processes. **c) Understands** the accountabilities of the professional engineer and the broader engineering team for the safety of other people and for protection of the environment. **d) Is aware of** the fundamental principles of intellectual property rights and protection.
3.2 Effective oral and written communication in professional and lay domains.	**a) Is proficient in** listening, speaking, reading and writing English, including: - comprehending critically and fairly the viewpoints of others; - expressing information effectively and succinctly, issuing instruction, engaging in discussion, presenting arguments and justification, debating and negotiating - to technical and non-technical audiences and using textual, diagrammatic, pictorial and graphical media best suited to the context; - representing an engineering position, or the engineering profession at large to the broader community; - appreciating the impact of body language, personal behaviour and other non-verbal communication processes, as well as the fundamentals of human social behaviour and their cross-cultural differences. **b) Prepares** high quality engineering documents such as progress and project reports, reports of investigations and feasibility studies, proposals, specifications, design records, drawings, technical descriptions and presentations pertinent to the engineering discipline.
3.3 Creative, innovative and pro-active demeanour.	**a) Applies** creative approaches to identify and develop alternative concepts, solutions and procedures, appropriately challenges engineering practices from technical and non-technical viewpoints; identifies new technological opportunities. **b) Seeks out** new developments in the engineering discipline and specialisations and **applies** fundamental knowledge and systematic processes to evaluate and report potential. **c) Is aware of** broader fields of science, engineering, technology and commerce from which new ideas and interfaces may be may drawn and readily **engages** with professionals from these fields to exchange ideas.
3.4 Professional use and management of information.	**a) Is proficient in** locating and utilising information - including accessing, systematically searching, analysing, evaluating and referencing relevant published works and data; is proficient in the use of indexes, bibliographic databases and other search facilities. **b) Critically assesses** the accuracy, reliability and authenticity of information. **c) Is aware of** common document identification, tracking and control procedures.
3.5 Orderly management of self, and professional conduct.	**a) Demonstrates** commitment to critical self-review and performance evaluation against appropriate criteria as a primary means of tracking personal development needs and achievements. **b) Understands** the importance of being a member of a professional and intellectual community, learning from its knowledge and standards, and contributing to their maintenance and advancement. **c) Demonstrates** commitment to life-long learning and professional development. **d) Manages** time and processes effectively**, prioritises** competing demands to achieve personal, career and organisational goals and objectives. **e) Thinks critically and applies** an appropriate balance of logic and intellectual criteria to analysis, judgment and decision making. **f) Presents** a professional image in all circumstances, including relations with clients, stakeholders, as well as with professional and technical colleagues across wide ranging disciplines.
3.6 Effective team membership and team leadership.	**a) Understands** the fundamentals of team dynamics and leadership. **b) Functions as** an effective member or leader of diverse engineering teams, including those with multi-level, multi-disciplinary and multi-cultural dimensions. **c) Earns** the trust and confidence of colleagues through competent and timely completion of tasks. **d) Recognises** the value of alternative and diverse viewpoints, scholarly advice and the importance of professional networking. **e) Confidently pursues and discerns** expert assistance and professional advice. **f) Takes initiative and fulfils** the leadership role whilst respecting the agreed roles of others.