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1) a) i) Responsible professionalism is to exhibit professional competence and personal integrity, incorporate cooperative practices and prioritise public well-being. This is especially important to engineers as their key role is to translate into action the dreams of humanity, traditional knowledge and concepts of science to achieve sustainable management of the planet through the creative application of technology. As engineering connects pure science to society, engineers have to exhibit responsible professionalism in order to live up to the standards the society expects of them, and hold paramount the good of society in their work, conduct and pursuit of technological developments.

ii) Moral values permeate all aspects of technological development, hence ethics and excellence in engineering go hand-in-hand. This theme is especially significant due to the dynamic and turbulent nature of engineering, where all aspects are multi-faceted and many factors, such as political, social, and economic factors, come into play at once. Such complexity brings in many moral values and gives rise to ethical dilemmas, thus responsible ethics and professional excellence are both required to navigate this minefield of dilemmas. For example, when Dolly the sheep was successfully cloned in 1996, University of Edinburgh, through cell nuclear transfer, it was met with both welcome and disdain. While the success of cloning animals will enable the preservation of endangered species from extinction, it could also bring about the cloning of humans, with very serious ethical issues. With its many implications, the excellence of the cloning experiment, if not guided by moral values, could spell disaster for humanity.

b) i) Galileo (1564 – 1642) invented the telescope to defend Copernicus' Heliocentric view of the universe, despite persecution by the Church. Not only has this enabled further research into space and study of our neighbouring cosmic bodies, it has also overturned the church's teachings, that the other planets revolved around the Earth. This breakthrough in science has led many to embrace well-proven scientific methods and teachings, breaking the church's incumbent hold on knowledge and disproving their claims and teachings, inspiring the many of the discoveries in the Scientific Revolution.

Isaac Newton (1642 – 1727) took Galileo's theory further and formulated an accurate model of the universe based on the law of universal gravitation, which is taught widely in schools and is the basis for many other scientific theories and processes.

ii) Moral autonomy is an important skill for us, to navigate the dynamic and multi-faceted environments in engineering, especially in the face of ethical dilemmas. Instead of giving in to pressure from superiors, peers, or the public, we be able to make independent decisions that we believe best meets the needs of the public.

Furthermore, the ability to remain steadfast and collected in the face of mounting pressure, is critical for any engineer. In increasingly complex and turbulent environments, where people's lives could even come under threat, an engineer

needs to remain calm and take the best possible course of action to ensure the safety and wellness of the people.

- 2) a) i) Foundation of Ethical Behaviour is built upon:
- a) Morality: Principles distinguishing between right and wrong
 - b) Ethical Standards: Principles guiding behaviour that is morally correct
 - c) Person's Moral Sense: Ability to differentiate between right and wrong

Whether a person has strong/weak ethical sense depends on his foundation of ethical behaviour. If his individual morality, ethical standards, or moral sense is warped, it may lead him to partake in unethical activities. For example, when there is personal gain to be made, some might be tempted into wrongdoing. It is difficult to ensure that all engineers will adhere to the proper ethical standards, even when faced with strict punishment, as seen in the Bhopal Union Carbide Plant incident. One of the key themes in the study of engineering ethics is "Promoting responsible conduct is even more important than punishing wrong-doing".

- ii) In the "Pfizer 2009" case study, John Kopchinsky, an employee turned whistleblower, leaked to the public and media that the company's management promoted drugs in large doses and for purposes not approved by America's FDA. He claimed, "In the army I was expected to protect people at all costs. At Pfizer I was expected to increase profits at all costs, even when sales meant endangering lives. I couldn't do that". John Kopchinsky had the moral autonomy and independence to fight for public welfare and expose the unscrupulous deeds of the higher management. He made this decision to stop people from being exploited by Pfizer, despite well knowing that he would suffer by losing his job. Thus, he exhibited moral autonomy in prioritising public welfare over personal gains.

- b) i) A profession is a (Any two below):

- Advanced expertise
- Self-regulation
- Public good

- ii) Boisjoly, when placed under pressure from his superiors, chose to give up and stop protesting the launch, and stood by while permission was given for the launch. In the end, the shuttle exploded mid-flight, killing everyone onboard. Boisjoly failed to ensure the safety of the flight crew, and chose to give up in pursuing excellence and safety, which may have prevented the explosion. In standing by and doing nothing, he had prioritised himself and his employment over the welfare of the flight crew, which is tantamount to abandoning his duties and failing to live up to expectations placed on him by the public.

- iii) As engineers, it is important to exhibit moral autonomy. As people who connect science with society, our actions can have various implications on society. It is important to think of the possible repercussions before we act, lest we bring harm upon society instead of creating benefits and doing good in society, as we are meant to. In the "NASA Challenger Space Shuttle" case study, the higher management were

thinking only from their own “management” perspective, taking into consideration the political benefits if the launch succeeds, and the backlash if they delay the launch. They did not believe in the “engineering” perspective, which warned of dangers and imminent destruction if they proceeded with the launch. While Boisjoly and the other engineers were fulfilling their roles as engineers in protesting against going ahead with the launch, they quickly abandoned their position when pressured by the management. If any of the staff involved had the moral autonomy to stand up and persevere in fighting for the most morally appropriate course of action, which is to delay the launch to fix the faults discovered, this disaster could have been prevented. The unnecessary deaths of the flight crew were brought due to lack of moral autonomy and perseverance of the engineers and managers involved in the project.

- c) i) The criterion set forth by the PEB are (Any 2 below):
- To hold an approved degree of qualification listed in the Professional Engineers (Approved Qualifications) Notification
 - To have acquired not less than 4 years of relevant experience
 - To sit and pass the Fundamentals of Engineering and the Practice of Professional Engineering examinations
 - To attend an interview
- ii) A PE shall engage, or advise engaging, experts, specialists when in his opinion and judgement such services are in the interest of his client/employer.

- 3) a) i) It is based on the utilitarianism framework, which emphasizes on producing the most good for the most people, giving equal consideration to everyone affected. NNS strongly emphasises on building ships of sufficient quality, to provide quality and safe trips for its passengers, even if it incurs a loss to the company. This is because NNS prioritises the safety and comfort of its passengers, and seeks to provide this good, for all its passengers, as per the utilitarianism framework.
- ii) Ethical dilemmas are situations in which moral reasons come into conflict and it is not clear what should be done. Ethical dilemmas arise due to the large myriad of factors such as political, social, and economic factors, as well as the different parties involved in the situation.

To navigate such murky situations, it is important to hold paramount moral frameworks that provide guiding principles on what should be done. For example, NNS strictly follows the utilitarianism framework as its company mission statement, and cherishes the safety and comfort of its passengers. This is compared to the Cost-Benefit Analysis that would emphasize on cost effectiveness and financial profits for the company, even at the expense of its passengers.

- b) i) SPRING stands for Standards, Productivity, and Innovation Board. Their role is to (Any 2 below):
- Champion standardisation initiatives to strengthen industry competitiveness, quality, safety, health and environment

- Participate/facilitate actively in international and regional standards forums to increase harmonisation with overseas markets
 - Lead the standards and conformance negotiations in Free Trade Agreements (FTAs) and Mutual Recognition Agreements (MRAs) to facilitate trade
- iii) Standards ensure interoperability, as products and materials that adhere to certain standards, approved by reputable statutory boards and organisations, promise a certain degree of quality, and can be applied uniformly to appropriate products or services, such as manufacturing processes. This eases sourcing of materials for manufacture or use, and gives rise to cost reduction. This also breeds mutual recognition as firms and consumers both recognise the standards and established quality that the product/service adheres to. Moreover, certain standards include clauses requiring assurance of the health and safety of the consumer and protection of the environment, in the manufacture and usage of the product/service. Overall, standards help to meet market needs, certain economic viability and spurs productivity and trade. Thus, considering the many benefits, it is important for us as engineers to develop products/services that adhere strictly to various standards where possible.
- c)
 - i) In our capacity as a Knowledge-Based Economy (KBE), there is a strong need for Singapore to have a robust regime for the protection of IP. Firstly, this will encourage innovation and enterprise by local entrepreneurs. Secondly, this will also attract investments, as a strong IP protection regime reassures investors that the IP of the products they are investing in is soundly protected, making Singapore an appealing hub for investment. The statutory board in charge of this regime is called Intellectual Property Office of Singapore (IPOS).
 - ii) Conduct a search to assess whether any IPs, such as features, processes or methodologies that one intends to adopt may be protected by IP rights owned by others.
 - One could make changes to their design in areas where the design is likely to infringe the IP rights owned by others.
 - One could also seek a license from the owner of the IP rights being infringed, or even seek to set up cross-licensing.
- 4) a)
 - i) In my opinion, the Japanese Occupation (1942 – 1945) has impacted Singapore most significantly. The “Sook Ching” operation conducted by the Japanese saw the ruthless massacre of many innocent local males as the Japanese sought to eliminate any dissenters. The harsh lives that the locals led in times of war spurred them to seek complete self-governance and independence, instead of relying on the British forces who abandoned them after suffering a defeat at the hands of the Japanese. They sought to have their own parliamentary system where they themselves will make the critical decisions regarding Singapore’s governance. To safeguard its sovereignty, Singapore introduced the National Service, where male youths after coming of age, are enlisted in the people’s army and trained to defend Singapore in times of war. Both make up the backbone of modern Singapore.

- ii) The key purpose of Psychological Defence is “to develop the collective will of Singaporeans to stand up for their rights, to protect what is theirs and to be left in peace to progress and prosper in their own way”. Therefore, strengthening the moral fibre of the population, which is increasing in numbers of diversity is key. It is operationalised through the National Education (NE) programme.

The key purpose of Civil Defence is “to equip the civilian population with the ability of respond in an organised manner during emergencies” In event of war, the role of Civil Defence is to protect civilian lives, lower the casualty rate, minimise damage to property, and pave the way to normalcy.

- b) i) Singapore is a parliamentary republic whereby the Prime Minister is the head of government, and the system is multi-party democracy. The President is the head of state, and his/her role is largely ceremonial except for some veto powers in a few key decisions such as use of national reserves and appointment of judiciary positions. The President is elected for a term of six years. In Singapore’s system of multi-party democracy, members of parliament from various political parties are elected by the citizens to represent them fairly in parliament and decision-making. The Parliament and the President jointly make up the legislature of Singapore.
- ii) In the borderless world of KBE, heavily influenced by globalisation and hyper-competition. Singapore has liberalised its industries (such as telecoms, banking and services). It has spurred development of its manufacturing and services clusters as its twin drivers of growth and also seeks to enlarge external economy. In its KBE strategy, Singapore seeks to further diversify FDI destinations to non-traditional countries like the Middle East and Latin America. Also, it seeks to integrate domestic and external economies to increase GNP and also continue to attract foreign talents. The reason for its adoption is to maintain economic resilience, spearhead economic redevelopment and reduce vulnerability.
- c) i) The shift toward a more integrated and interdependent world economy. The two macro factors are
- Decline in barriers to the free flow of goods, services, and capital that has occurred since the end of World War 2, as countries seek to spur post-war recovery and growth by increasing external trade.
 - Technological change. Improvements in communication, information processing, transportation technology has made it feasible, efficient and cost-effective to transport goods to other countries over a large distance, enabling global trade.
- ii) “Globalisation of Production” refers to sourcing of goods and services from locations around the world to take advantage of differences in cost or quality of the factors of production in labour, land and capital.

Famously known as the Little Red Dot, Singapore is a small country with a small workforce. Thus, Singapore and its industries benefit hugely by tapping on other

countries bountiful with land and labour resources, such as China and India, where manpower and land is much cheaper. For example, many Singapore firms are taking advantage of modern communication technology, and particularly the Internet, to outsource service activities to low-cost producers in other nations.

The huge cost advantage provided by globalisation of production allows Singapore firms to reduce its cost price and price its products more competitively in the global market, increasing sales and revenue, spurring Singapore's economic development.

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