TUS
Technological University of the Shannon:
Midlands Midwest
Ollscoil Teicneolaíochta na Sionainne:
Lár Tíre Iarthar Láir

Leaving Certificate Engineering Prescribed Topic 2024

Design, Operation and Technology of Container Ships

Presented by David Sims, Dept of Electrical and Electronic Engineering.

Engineering Week 2023
#TUSEngWeek

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List of Acronyms

AIS	Automatic Identification System
AR	Augmented Reality
BIC	Bureau of International Containers
DWT	Dead Weight Tonnage
ECDIS	Electronic Chart Display and Information System
FRP	Fiber-Reinforced Plastics)
GPS	Global Positioning System
ISO	International Standards Association
LNG	Liquefied Natural Gas
TEU	Twenty Foot Equivalent Units

Foreword

Thank you for attending the 26th Engineering week here on our Moylish campus, in the Technological University of the Shannon – Midwest. Engineering week 2023 is co-hosted by both the Electrical & Electronic Engineering and the Mechanical & Automobile Engineering departments, both of which are in the Faculty of Engineering and the Built Environment.

We are delighted to have had you on campus for the presentation on this year's engineering leaving certificate special topic and a tour of our engineering facilities. We trust that this handout will help you when answering the special topic questions in the leaving cert exam in June.

If you are considering a career in engineering, we hope that the tour you were given will help make your mind up with regards the various different disciplines in engineering. We have over 20 courses in engineering here in TUS – Midwest at a range of levels which are broken down as follows ;

Apprentice Trades (3 to 4 years)	Level 6 - Higher Certificate (2 years)
Level 7 – Degree (3 years)	Level 8 – Honours Degree (4 years)

A full list of all of our engineering courses, with a QR code for each one can be found at the end of this booklet.

We would, once again, like to thank David Sims for his time in putting together the presentation and the information for this handout. We would like to thank our Dean of Faculty, the Marketing Department, both Heads of Department, and all of the staff and students of both departments who gave of their time to help with the 26th Engineering Week 2023

We would like to especially thank Joe Leddin of the Mid West Regional Skills for his generous sponsorship of this event.

1 Introduction

Maritime shipping has historically been a high cost and logistically complex undertaking. The invention of standardised shipping containers revolutionised the industry. In 1956, Malcolm McLean, a trucking business owner, collaborated with engineer Keith Tantlinger to design the first standardised shipping container. McLean's visionary system enabled cargo to be seamlessly transported across trucks, trains, and ships, without the need for unloading and reloading, or even opening the container. This marked a significant leap in operational efficiency. Although not the first attempt at containerization, McLean's design dramatically slashed shipping costs and times, spurring a rapid expansion in international trade. This innovation is widely acknowledged as one of the pivotal developments in global commerce history. Today, the carrying capacity of container ships is quantified in Twenty-Foot Equivalent Units (TEUs), with each TEU representing the volume of a standard 20-foot container. The three largest container ships at the time of writing, all owned by a large global container shipping company called MSC, can each carry 24,346 TEUs.

In the ongoing pursuit of efficiency and profitability, the shipping industry has continually sought technological innovations to enhance capacity, streamline operations, and reduce costs.

While the sector's evolution toward larger ships and advanced technology offers many benefits, it's not without challenges. For example, larger vessels put significant pressure on smaller ports, requiring expensive upgrades to accommodate them. The 2021 incident at the Suez Canal, where a large container ship, the Ever Given measuring 400m in length, ran aground as shown in Figure 1, underscores the challenges involved. The Suez Canal was closed for six days causing a traffic jam of over 300 ships and causing significant delays to worldwide shipping and resulting in the Ever Given and its cargo being impounded for over 100 days.

Figure 1. Satellite image of blocked Suez canal (https://eol.jsc.nasa.gov)

Additionally, the rise in digitalization, while improving operations, also opens the door to cyber threats, a major example of which was seen in the 2017 Maersk ransomware attack. Maersk are a Danish shipping and logistics company and regarded as the second largest container shipping company in the world. At the time it affected nearly 80,000 employees in 574 offices in 130 countries. It triggered an emergency shutdown of all its PC's and devices, considered to be one of the biggest cyberattacks in history. It cost the company and estimated $300 million and disrupted shipping operations for two weeks.

Each generation of container ships brings advancements in design, automation, and sustainable practices, ensuring the industry's ongoing relevance and resilience as a vital component of global trade. Ireland has eight major ports that are capable of handling container ships ; Port of Dublin, Port of Galway, Port of Shannon Foynes, Port of Bantry Bay, Port of Cork, Port of Drogheda, Port of Waterford and Port of Fenit.

According to the Irish Central Statics Office in a June 2023 report, Irish ports handled 53 million tonnes of goods in 2022. Some key findings of that report were as follows ;

- Total tonnes of goods handled by Irish ports in 2022 was 53,155,000 which decreased by 1% compared with 2021.

- During 2022, 12,447 vessels arrived in Irish ports, compared with 12,713 in 2021.

- Dublin port accounted for 59% of all vessel arrivals in Irish ports in 2022.

- Goods forwarded from Irish ports amounted to 16.9 million tonnes in 2022, while a total of 36.3 million tonnes of goods were received.

As a comparison, 240 tourist cruise ships arrived into Irish ports in 2022. A breakdown of imported and exported goods into and out of Ireland can be seen in Figure 2. In comparison we handled 37,000 tonnes of air freight into and out of our airports for the first quarter of 2023. This makes an estimated 148,000 tonnes per year by air, which is less than 1% that is transported by sea.

Figure 2. CSO figures for Ireland's trade goods in 2021.

2 Design

Modern container ships, which are a specific type of cargo ship, are designed around balancing container capacity with speed and safety which requires several trade-offs surrounding their design.

2.1 Container Design

The dimensions of intermodal containers are heavily influenced by land transport infrastructure. They must be sized to navigate through tunnels and under bridges. Additionally, the weight of the cargo they carry is largely dictated by the capabilities of road trucks. In Ireland, Road Haulage regulations stipulate a gross vehicle weight limit of 44,000 kg. This encompasses the vehicle, trailer, and cargo. For a 20-foot container, the maximum approximate cargo weight is 27,000 kgs, while for a 40-foot container, it's 25,500 kgs. These limits highlight the necessary trade-offs between container size and cargo weight.

Most contemporary intermodal containers align with ISO (International Standards Organisation) standards, which primarily recognize 20-foot and 40-foot containers. The dimensions refer to their external length. Both these variants typically have a width of 8 feet (2.43 meters) and a height of 8 feet 6 inches (2.59 meters). A 20 foot container has a volume of 1,151 cubic feet (32.6 m^3) while a 40 foot container has a volume of 2,366 cubic feet (67 m^3). Adhering to these standardised dimensions ensures that containers can be seamlessly transported globally.

Refrigerated containers, or "reefers", have specialised designs. While their primary use is to transport perishable items, they are also employed to transport specific goods requiring temperature control, such as certain chemicals. These containers connect to the ship's power supply and are often placed in designated sections of the cargo hold for optimal monitoring and safety. There are several other types of containers, including tank containers for liquids or open-top containers for oversized cargo.

2.2 Vessel Size

The size of container ships is often influenced by the routes they need to travel, especially when navigating natural waterways and man-made canals. For instance, the Strait of Malacca, which connects the Indian Ocean and the Pacific Ocean, is an important shipping route. However, two major canals have an even more direct impact on ship design. Utilising these canals can greatly influence the speed and profitability of shipments.

The Suez Canal, opened in 1869, connects the Mediterranean Sea to the Red Sea, providing a shortcut that eliminates the need to sail around Africa when moving goods from Asia to Europe. Ships designed to the maximum specifications for this canal are termed "Suezmax".

The Panama Canal, unveiled in 1914, bridges the Pacific and Atlantic Oceans between Central and South America. Historically, the largest ships that could navigate this canal were labelled "Panamax". However, after the canal's expansion in 2016, the "Neopanamax" class was introduced, allowing for larger vessels in both length and width. This canal features a series of locks, as shown in Figure 3, designed to elevate ships from sea level to the height of Gatun Lake, 26 metres above. The dimensions of these locks, coupled with the heights of bridges along the route, are key factors determining the maximum size of ships that can pass through. The evolution of vessel sizes are shown in Figure 4.

Figure 3. Panama Canal Locks (https://commons.wikimedia.org)

In the context of vessel size and capacity, Dead Weight Tonnage (DWT) plays a pivotal role. DWT measures the total weight a ship can safely transport, which encompasses cargo, fuel, fresh water, provisions for the crew, and even their personal effects. It is a crucial parameter in ship design, dictating the maximum permissible load and thereby influencing the design choices made to ensure maritime safety and efficiency. For example, a ship with a DWT of 100,000 can carry up to 100,000 tons of cargo and necessities. As ships grow larger to accommodate more containers, their DWT also increases, allowing for more efficient transportation of goods in bulk, which is a key factor in the economics of international trade. The timeline of the development of the sizes of container ships is shown in Figure 4.

Figure 4. Evolution of container vessel size (https://www.porteconomics.eu).

2.3 Engine size and type

The size and type of engines used on board container ships has grown to match the size of the vessels themselves. Given the massive power outputs required by them they are predominantly diesel engines.

According to the website, https://interestingengineering.com, the world's largest engine in 2016 was the Wärtsilä RTA96C-14 as shown in Figure 5. It was designed for the Emma Maersk ship which can ship 11,000 containers and is classified as a New Panamax size of vessel. The engine provides an output of 109,000 HP (80 MW) weights 2,100 metric tonnes and measures 14 m tall by 28 m long. It consumes 6,400 liters of diesel per hour.

Figure 5. Worlds largest engine in 2016 (https://interestingengineering.com)

Due to current climatic conditions and international agreements, developments in electric ships is ongoing. The Yara Birkeland which features in Section 5.5 Enhanced Connectivity, is one of the first fully electric ocean going ships. Dubbed 'the Tesla of the seas' this fully-electrified, fully-autonomous cargo ship is already making waves. The Yara Birkeland has a 7MWh battery, charged by Norwegian hydro power. It can carry a little over 100 containers. The ship cost about 25 million dollars, about three times a "conventional ship price", but will nonetheless cut operational expenditure for the Yara company by 90 percent.

2.4 Hull Design and Efficiency

The design of a ship's hull is optimised for hydrodynamic efficiency, ensuring efficient movement through water. Constructed from high-strength steel, the hull provides the necessary durability to support the heavy load of stacked containers. Although high-strength steel is susceptible to corrosion due to constant exposure to saline water, this is mitigated by attaching sacrificial anodes made from metals like zinc, aluminium, or magnesium. These metals have a more negative electrochemical potential than steel, causing them to corrode preferentially and save the steel hull. This process is known as cathodic protection and is required for any steel vessel or ship.

The hull, being the main body of the ship, encompasses the bottom and sides of the vessel, providing buoyancy and structural integrity. Its streamlined shape, including a bulbous bow, minimises resistance and wave-making, which reduces drag and fuel consumption. Additionally, the design features a double bottom, which offers protection against grounding and minor collisions, contributing structural rigidity and adding longitudinal strength to the ship's design.

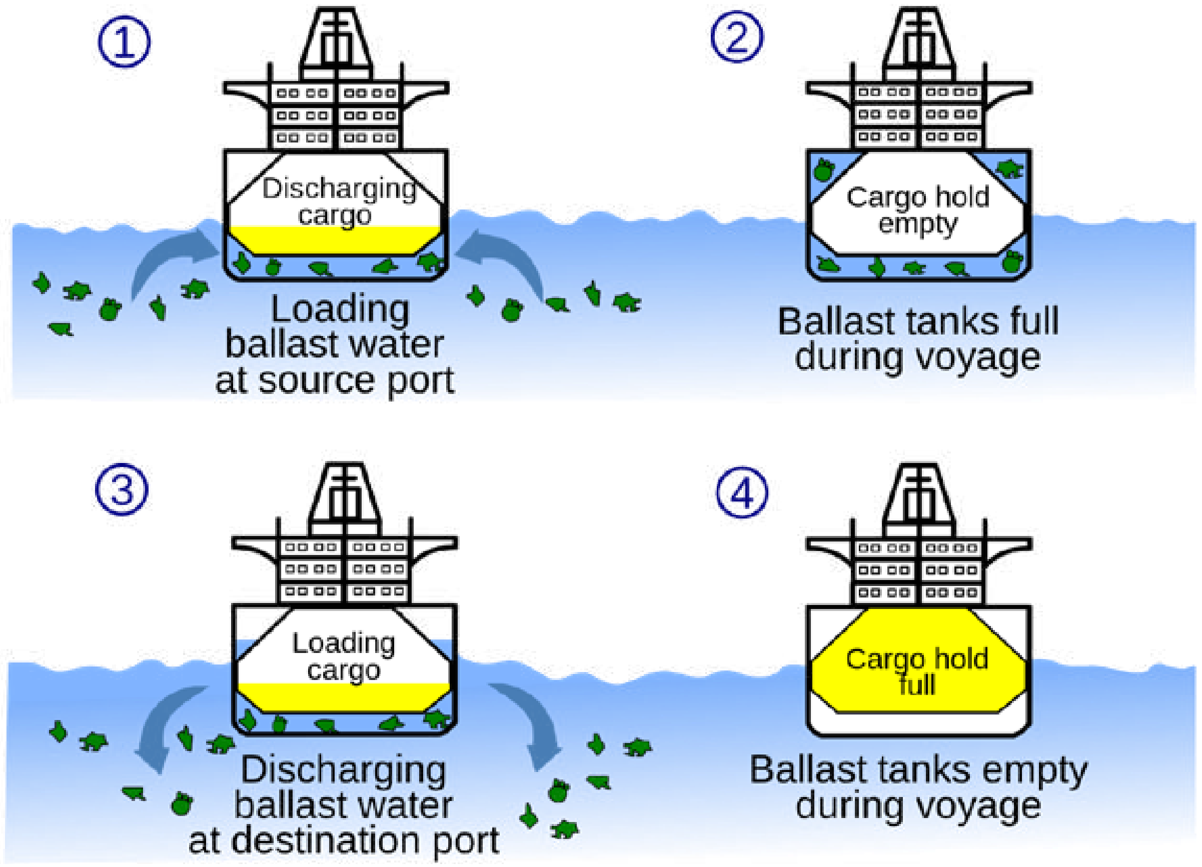


Figure 6. Ballast water discharge sequence (https://commons.wikimedia.org).

The space within the double bottom houses ballast tanks, which can be filled or emptied to adjust the ship's stability and maintain optimal trim (its longitudinal tilt) and draft (the depth below the waterline).

Wing tanks, located on the sides of the hull, also contain ballast water, as shown in Figure 6. This water is managed according to strict environmental regulations to prevent ecological contamination when discharged into the sea. Some ports and regions will check the ship's ballast water and not allow discharge into their waters for ecological and environmental reasons.

The operational speed of container ships, commonly referred to as service speed, and the duration of their voyages are major considerations in the design phase. These vessels are typically designed to maintain a balance between speed and fuel efficiency, as higher speeds increase fuel consumption exponentially. The service speed for most modern container ships ranges between 20 to 25 knots, with the design speed often being a few knots higher to provide a margin for adverse conditions. A typical voyage from China to Northern Europe via the Suez Canal is roughly 35-45 days in duration.

2.5 Vertical Dimensions and Stability

The vertical dimension of the ship, or its height, is a critical aspect of design that has far-reaching implications for operational functionality and safety. The height of a container ship, particularly above the waterline, must be carefully calibrated. Excessive height can lead to increased wind resistance, which affects fuel efficiency and manoeuvrability. It also poses challenges for the clearance of bridges and the operational range of port cranes.

The stacking of containers, particularly on deck, must be meticulously planned not only to optimise space and ensure the line of sight from the navigation bridge remains unobstructed, but also to preserve the vessel's centre of gravity and maintain metacentric height, which is crucial for preventing excessive heeling (listing or leaning to one side). Metacentric height is a measure of stability. Its the distance between the ship's centre of gravity and the metacentre, the point where buoyancy forces act when the ship is tilted.

Height considerations extend into the design of the superstructure and mast systems, which must be proportionate to the vessel's overall dimensions to maintain the optimal balance between structural integrity and navigational efficiency. Ships masts which traditionally were used to hold the sails are now used for navigational & communication equipment as well as lighting.

In the context of container stacking, the advent of higher stacks on deck underscores the importance of maintaining a favourable metacentric height to ensure the ship's stability under various loading conditions. This need for advanced lashing systems to secure the cargo against the forces encountered at sea becomes even more critical with increased stack height. Robust engineering solutions are required to manage the additional weight, influencing the buoyancy and stability characteristics of the ship, and ensuring the structural integrity and safe operability of the vessel in all sea conditions.

2.6 Structural Integrity and Load Distribution

The outer structure of a container ship, including the wing tanks, is designed as a torsion box, contributing to the vessel's overall longitudinal and torsional strength. Wing tanks are located along the sides of the vessel within the bottom wing of each cargo hold. Additionally, the vessel's transverse strength is reinforced by deep web frames, which fortify the ship against lateral stresses, as shown in Figure 7. As waves can exert forces in several directions it is important that these structures ensure the overall stability and durability in harsh sea conditions.

Figure 7. Internal web frames of a ship give it additional strength (http://www.portpictures.nl).

Cargo on these ships is stowed in the holds below deck and on deck, with deck hatches providing access to the below-deck storage areas. Within the holds, cell guides facilitate the precise placement and stacking of containers, enhancing loading efficiency and cargo security. Containers on deck are secured using lashing rods and turnbuckles (shown below in Figure 8), ensuring stability throughout the voyage.

Figure 8. Turnbuckles used to secure containers on board a ship (en.m.wikipedia.org/).

2.7 Design Innovations

Innovations in modern container ship design include the elimination of fixed decks for cargo storage, allowing for the stacking of containers to greater heights. This design forgoes traditional deck structures, which typically act as barriers to water ingress. Instead, any water that enters the cargo area is actively managed and expelled through pumping systems. Such an open design enhances air circulation, which is particularly beneficial for the dissipation of heat from refrigerated containers, thereby improving the efficiency of the ship's cooling systems and maintaining the integrity of temperature-sensitive cargo.

2.8 Superstructure and Visibility

On a container ship, the navigation bridge, officer and crew accommodations, and machinery control spaces are contained in a Superstructure towards the aft (rear) of the vessel. It provides a clear line of sight over the containers and for navigation purposes. Having the superstructure and engine room near the ship's propulsion system simplifies the layout of mechanical and electrical connections.

3 Operation

The logistics and coordination that go into the operation of container ships is as impressive as their size and can be divided into the following sections ;

3.1 Navigation and Route Planning

The ships contain a multitude of sensors and radars that enable them to navigate using modern technology. GPS (Global Positioning System) provides accurate location data, allowing the ship's crew to always know the vessel's exact location. AIS (Automatic Identification System) is a local transmission from each ship that provides position, speed, and course to help with collision avoidance and traffic management at ports. Radar is used to detect other ships, obstacles, and land masses, especially when there is poor visibility.

Access to detailed weather forecasts is very important, it allows ships to adjust their routes to avoid storms or take advantage of favourable conditions. Modern ships can access real-time weather data.

While it is the ship's officers' role to interpret all this data, software is also used to plan the most efficient route, considering the size of the ship, distance, currents, and fuel consumption.

Paper charts have largely been replaced with electronic versions, known as Electronic Chart Display and Information System (ECDIS), which can incorporate data from various sources, including GPS, AIS, and weather data to provide a comprehensive navigational picture.

3.2 Stowage Planning

Before arrival at a port, a specialist team of the ship's crew coordinates a stowage plan. This dictates where each container is placed on the ship, considering factors like destination, weight, and type (e.g. refrigerated). Each container has a unique identifier and must be registered with the Bureau of International Containers (BIC) as per the ISO standard. The BIC number contains letters and digits that identify the company, country, type of container and other relevant information. This enables the containers to be tracked and properly dealt with by customs. Proper stowage planning ensures the balance and stability of the ship and that containers destined for the next port are easily accessible, reducing the time spent at each port. Software solutions exist that can ensure the optimal placement of containers. This has been put to good use in most ports, for example in Fenit harbour in Co. Kerry where Liebherr cranes are loaded onto container ships as shown in Figure 9.

Figure 9. Liebherr cranes being loaded onto a ship in Fenit, Co. Kerry (Kerryman - Independent.ie).

3.3 The Berthing Process

Given the size of container ships and the equipment needed to unload them, cargo ships can only dock at specialised ports. Navigating a port and correctly berthing the ship can be a difficult process for a captain that is unfamiliar with the area. Local pilots are often called on to board the ship and guide it safely to berth using their expert knowledge of the local waters. This can be dangerous as the pilot needs to board the cargo ship from a smaller boat which can be complicated by the sea conditions. A high number of pilots have been injured or killed when boarding a ship. When the pilot is on board, they are ranked the same as the ship's captain. The use of a pilot is usually mandated by the port if the ship's captain hasn't been trained in navigating the particular port. When transiting the major canals, a pilot who is employed by the canal authority, is required.

While some vessels have bow and stern thrusters that allow them to move sideways, they may also require the use of tugboats, small powerful boats assist the larger ships in manoeuvring by pushing the ship into place as shown in Figure 10. This is a delicate operation as too much force from the tugboats may cause the ship to hit the wall of the port or even topple over.

Figure 10. A tugboat manoeuvring a ship in the Panama canal (www.en.wikipedia.org/wiki).

3.4 Container Terminals

There are designated areas within ports equipped with the necessary infrastructure to handle container ships. A large quayside is required to accommodate the cargo ships and gantry cranes. Gantry cranes are massive cranes that can move back and forth along the length of the quay and reach over to lift containers on and off the ship as shown in Figure 11. There are areas within reach of the crane to stack the containers where specialised vehicles such as reach carriers and straddle carriers move containers around within the terminal or place them onto trucks and trains.

Figure 11. Containers being loaded in the port of Hamburg (https://commons.wikimedia.org).

Many of the larger ports now have fully or partially automated systems, with cranes remote controlled from a control room without needing a human to be on board. Increased speed and reducing human error are some of the benefits of automation, ensuring that the container ships are loaded and unloaded in an even shorter time, increasing the throughput of the port.

3.5 Security

Piracy is still a risk on the open seas, with attempts being made to either steal valuable cargo, or to hold the ship and crew members to ransom. Container ships, like all merchant ships, do not carry arms but they do have water cannons that can be used to deter attempts at boarding. This was the topic of a 2013 film staring Tom Hanks called Captain Philips as shown in Figure 12.

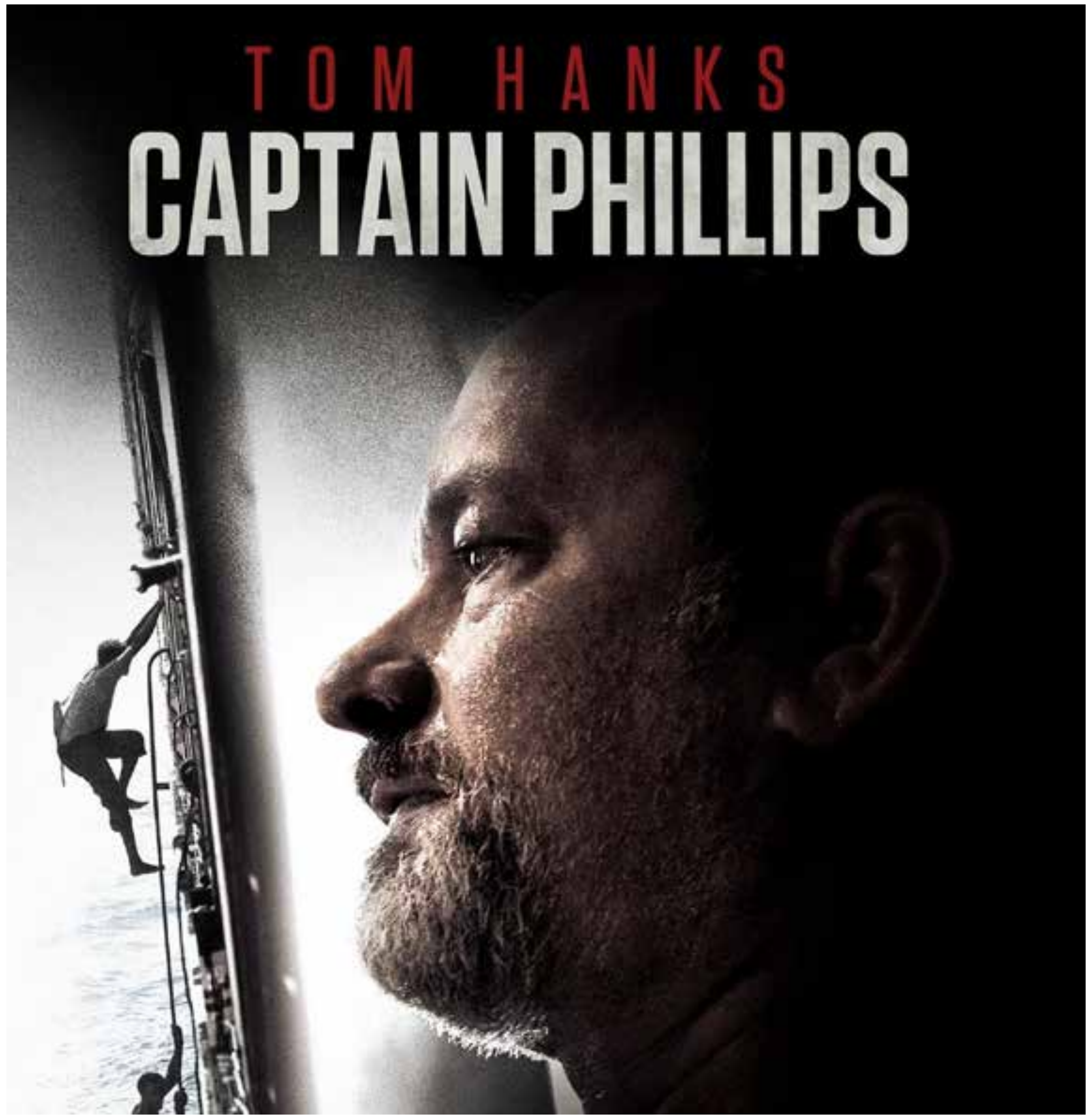


Figure 12. Captain Philips Movie (https://www.rottentomatoes.com/m/captain_phillips).

4 Technology

As the backbone of global trade, container shipping has always been at the forefront of adopting innovative technologies to enhance efficiency, safety, and environmental sustainability. With the industry continuously evolving, the integration of advanced technologies is shaping the future of maritime logistics.

4.1 Materials and Construction

The exploration of cutting-edge materials for hull construction goes beyond high-strength steel. Modern container ships may feature specialised coatings and composite materials that combat biofouling, minimise corrosion, and reduce friction between the ship's hull and the water. These technological advancements extend the lifespan of vessels and improve their hydrodynamic performance, resulting in substantial fuel savings and reduced emissions. According to a 2021 report by Horizon (the EU research & innovation magazine) "New materials to make ships more sustainable and less noisy for marine life". These new materials include composites such as FRP (Fiber-Reinforced Plastics) instead of steel. This will reduce weight and thus fuel consumption as well as increasing the ship's lifetime as shown in Figure 13. The added benefit of switching to composites will be to increase the recycle fraction. It is estimated that 34% of steel ships are repurposed while up to 75% of composites could be recycled.

Figure 13. New materials to make ships more sustainable and less noisy for marine life (www.europa.eu).

4.2 Propulsion Innovations

Progress in propulsion technology is one of the main ways that shipping is working towards a greener future. The transition to Liquefied Natural Gas (LNG) as a fuel source, for instance, marks a significant step in curtailing pollution, aligning with stringent environmental regulations. The exploration of hybrid and fully electric propulsion systems reflects the industry's commitment to sustainable practices. Several companies are providing LNG retrofits simultaneously with other modifications such as jumboisation, the process of adding a new section to an existing ship.

The industry is also embracing technologies aimed at reducing energy consumption. Innovative energy-saving devices, such as ducts and propeller fins, alongside air lubrication systems, are being adopted to lower resistance and enhance fuel efficiency.

4.3 Environmental Concerns

Technological advancements in environmental management are evident in the deployment of ballast water treatment systems and exhaust gas scrubbers. These innovations are critical in mitigating the ecological impact of shipping, preventing the spread of invasive species, and reducing airborne pollutants.

Growing economies will see the demand for freight transport triple by 2050. While nearly three-quarters of the world's cargo is carried by ocean-going ships, road vehicles like trucks and vans make up the majority, 74%, of freight's emissions, as explained in Figure 14. According to the Climate Portal in M.I.T. freight transportation makes up 8% of global greenhouse gas emissions as shown in Figure 15.

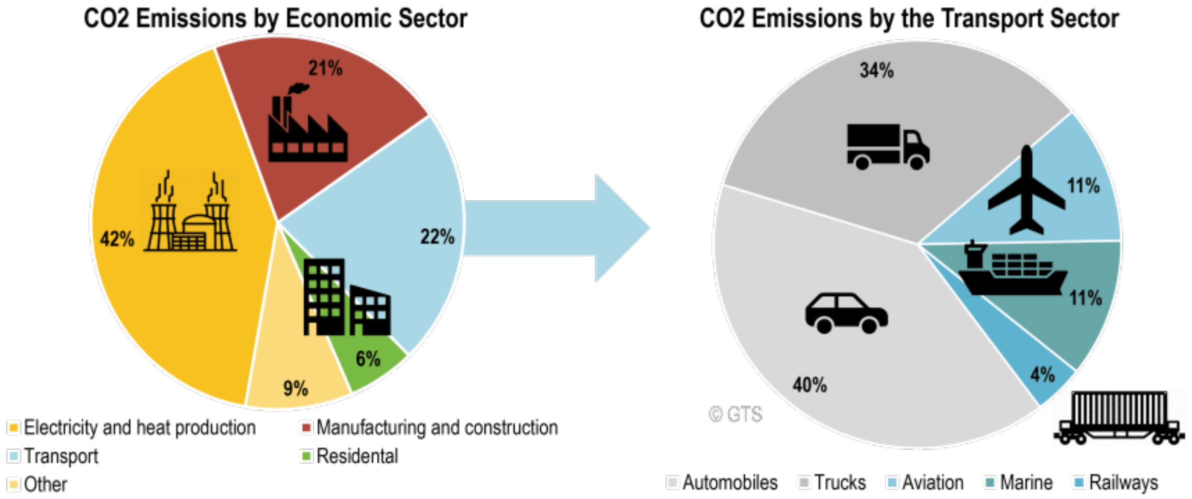
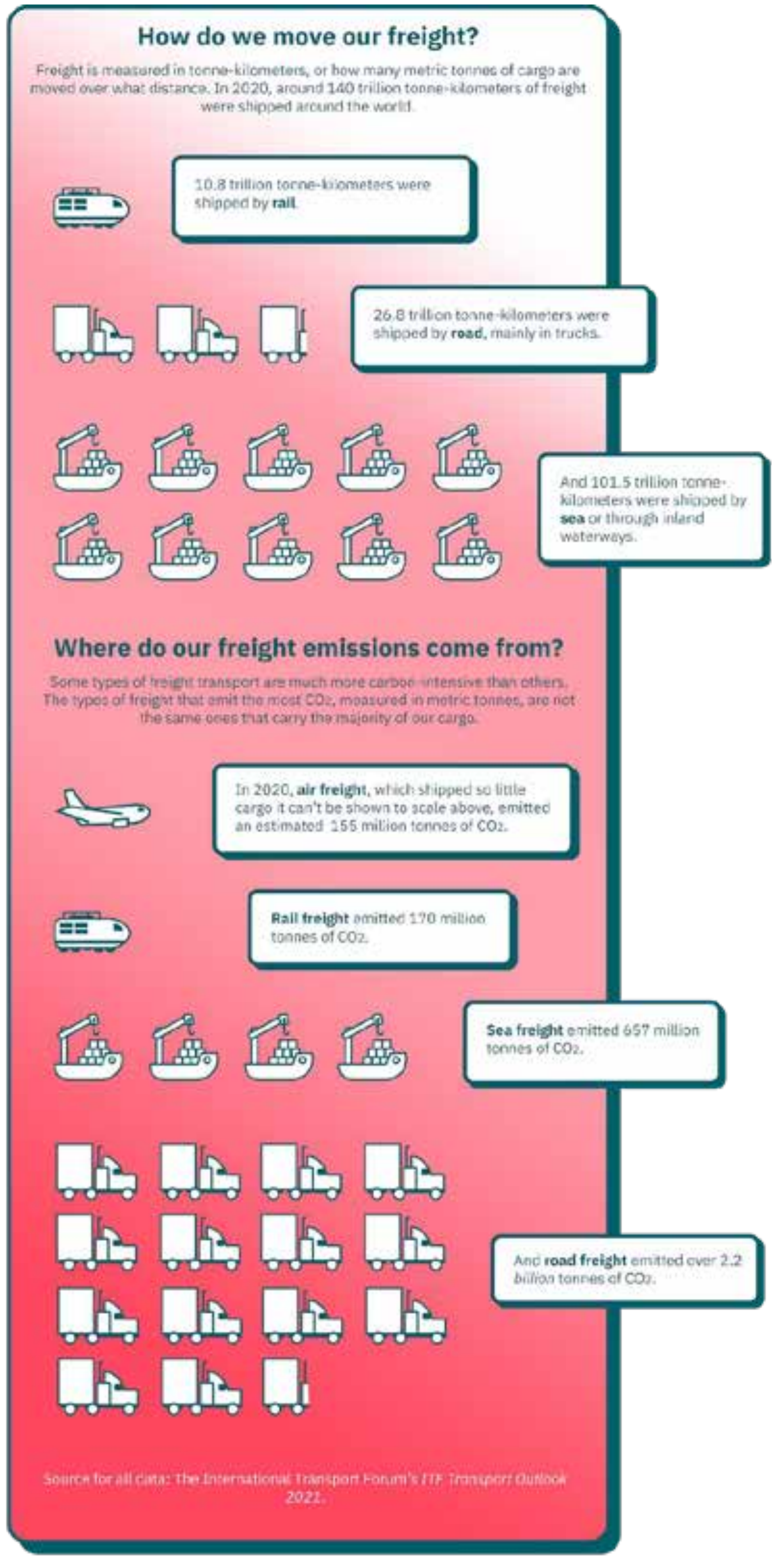


Figure 14. Global Greenhouse Gas Emissions by the Transportation Sector (transportgeography.org).



How do we move our freight?

Freight is measured in tonne-kilometers, or how many metric tonnes of cargo are moved over what distance. In 2020, around 140 trillion tonne-kilometers of freight were shipped around the world.

10.8 trillion tonne-kilometers were shipped by **rail**.

26.8 trillion tonne-kilometers were shipped by **road**, mainly in trucks.

And 101.5 trillion tonne-kilometers were shipped by **sea** or through inland waterways.

Where do our freight emissions come from?

Some types of freight transport are much more carbon-intensive than others. The types of freight that emit the most CO2, measured in metric tonnes, are not the same ones that carry the majority of our cargo.

In 2020, **air freight**, which shipped so little cargo it can't be shown to scale above, emitted an estimated 155 million tonnes of CO2.

Rail freight emitted 170 million tonnes of CO2.

Sea freight emitted 657 million tonnes of CO2.

And **road freight** emitted over 2.2 billion tonnes of CO2.

Source for all data: The International Transport Forum's *ITF Transport Outlook 2021*.

Figure 15. Freight Transportation (https://climate.mit.edu).

4.4 Automation and Digitalization

The advent of automation in container shipping has brought about a paradigm shift. Robotic systems now undertake tasks ranging from loading and unloading to inspections, ensuring precision and safety. Digitalization has made its way into every part of operations, from data-driven route optimization to predictive maintenance.

4.5 Enhanced Connectivity

Advanced satellite communication networks have removed the notion of isolation at sea. These systems provide robust connectivity that facilitates real-time data exchange, ensuring seamless operations and enhancing the welfare of the crew with improved access to communication services. This type of connectivity has also brought about the era of the "smart container", a concept that is transforming cargo monitoring. These containers are equipped with an array of sensors, enabling real-time tracking and monitoring of the cargo's condition, which is pivotal for sensitive shipments.

According to PierNext the year 2025 will see the arrival of ship automation. The Norwegian 120 TEU vessel, Yara Birkeland, has already completed a voyage in November 2021 that demonstrated the capabilities of autonomous technologies as shown in Figure 16. It is also one of the first fully electrically powered vessels as explained earlier in section 3.3 Engine size and type.

Figure 16. Inside The World's First Electric Cargo Ship - Yara Birkeland — Sustainable Ships (sustainable-ships.org).

4.6 Augmented Reality

The integration of Augmented Reality (AR) into navigational systems is a great example of a technological advancement being adopted in industry as shown in Figure 17. By overlaying navigational information from GPS and AIS directly onto the bridge's view, AR assists the crew in manoeuvring through intricate or busy waterways, elevating both safety and efficiency.

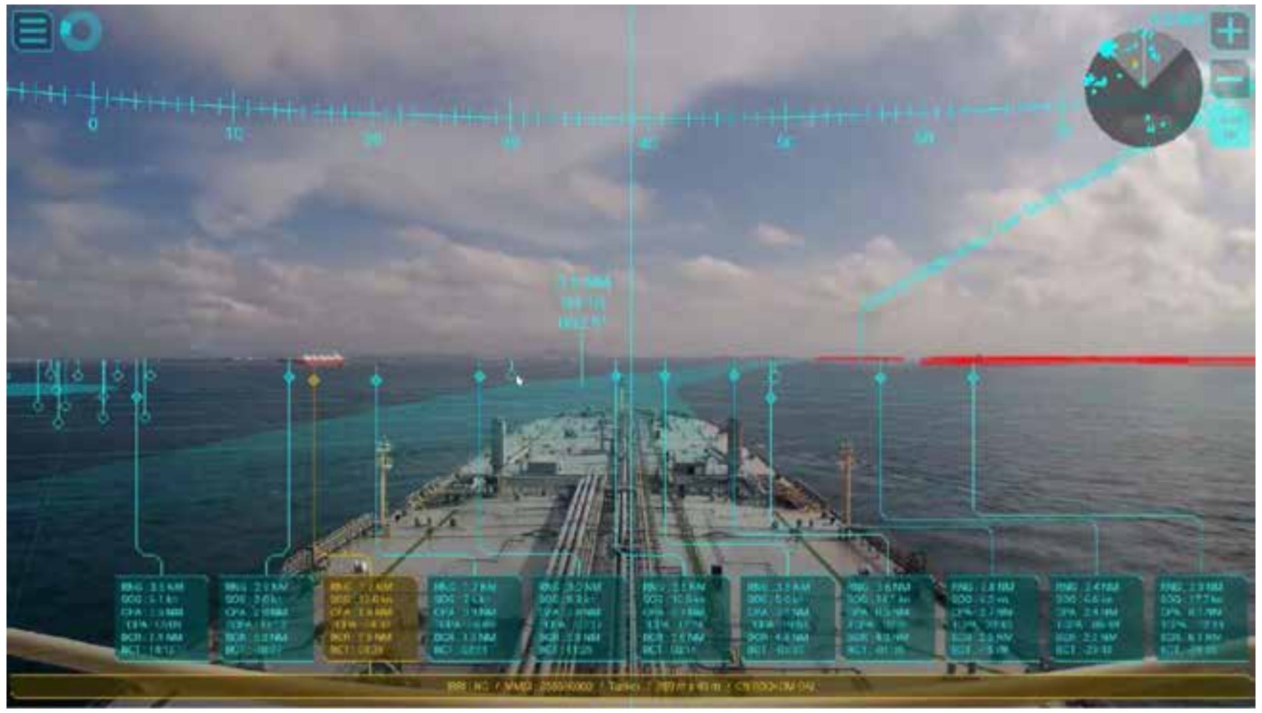


Figure 17. Bridge view enhanced with augmented reality. (https://www.mol.co.jp).

4.7 Onboard Manufacturing

The use of 3D printing technology on container ships is paving the way for on-demand manufacturing of spare parts. While the parts being printed are currently small, this can potentially revolutionise inventory management and reduce the need for extensive storage space. On board manufacturing also helps to keep delays to a minimum as a part can be manufactured enroute instead of waiting for a part to be shipped to the next port, potentially resulting in delays. The need for traditional methods of manufacturing such as turning, milling and machining still exists.

4.8 Cybersecurity

In addition to threats from pirates, with digitalization comes the threat of hackers. Container ships are now equipped with sophisticated defence mechanisms to safeguard navigational and operational systems from cyber threats, ensuring the integrity of maritime operations. The types of attacks could range from standard hacking attempts to compromise the crew’s personal devices, to potentially sophisticated infiltrations using smart containers loaded with malware. Recall the example of the 2017 Maersk ransomware attack, detailed in the introduction section on page 3.

5 Conclusion

The industry's evolution is reflective of its innovative past and adaptive nature. The advancements in design, operation, and technology have not only streamlined global trade but have also opened new frontiers for efficiency, safety, and environmental stewardship.

The industry seems poised to embrace more sustainable and intelligent shipping practices. The shift towards alternative fuels and propulsion systems hints at a greener future, with LNG and electric propulsion heralding the dawn of an eco-friendlier fleet. Moreover, as environmental regulations tighten, ships will increasingly incorporate technologies to reduce ecological footprints, from advanced coatings that reduce biofouling to sophisticated ballast water treatment systems.

Automation and digitalization will further revolutionise operations. The integration of AI, enhanced connectivity, and smart systems will transform traditional navigation and cargo handling into seamless, highly efficient processes. The "smart container" is set to redefine cargo monitoring, offering real-time data that ensures the integrity of goods across vast distances.

Cybersecurity will become paramount as the industry relies heavily on digital infrastructures. Proactive measures and advanced defence systems will be integral to protect against the growing threat of cyber-attacks.

Innovation continues beyond the ship's design and operation into the realms of augmented reality and onboard manufacturing. AR technologies promise to enhance situational awareness for safer navigation, while 3D printing holds the potential to revolutionise logistics and inventory management aboard ships.

The container ship sector, integral to global commerce, stands at a pivotal point. It must balance the demands for growth with the necessity for sustainable and responsible shipping. The coming years will likely witness a continued push towards cleaner, smarter, and more efficient practices, solidifying the industry's role as a cornerstone of international trade and a leader in technological adoption. The journey of container shipping is ongoing and ever evolving, with the future always promising new discoveries and innovations.

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7 Why pick a course in Engineering : F.A.Q.

The following are questions we are often asked by students who are thinking of picking a course in engineering. We hope that some of these answers will help you make up your mind.

What makes for a good engineer ?
An engineer is someone who is inquisitive about how things work, why and how they are made, and wonders if they could be improved upon. They tend to be good at thinking logically and like problem solving.

What is an engineer (answer from ChatGPT) ?
“An engineer is a professional who applies scientific and mathematical principles to design and create solutions for technical problems. Engineers work in various fields, such as civil, mechanical, electrical, chemical, aerospace, and computer engineering, among others. They use their knowledge and skills to design, analyse, test, and improve systems, structures, devices, and processes.”

Are there good job prospects for engineers ?
At the time of writing of this handout, yes there are. However by the time you might be graduating as an engineer, it could be June 2026, 26 or 27. Who can tell what the jobs market will be like then, which goes for any course you might pick. What we can say is engineering is broad disciplined qualification and graduate engineers are usually in good demand.

Is there work placement on the courses ?
All of our three year level 7 and four year level 8 courses come with a minimum of 5 months work placement, usually in 3rd year. The two year level 6 in Agricultural Mechanisation also features work placement.

Why should I not focus on the C.A.O. points ?
You should pick a course on the basis of what you are going to be studying in college for 2, 3 or 4 years, and the area/industry sector you see yourself working in, after you graduate. C.A.O. entry points constantly change and it’s unfortunately a common mistake to select your course based on this year’s points. Select your courses (10 Level 6/7 and 10 Level 8 courses) in the genuine order of the one you most want to do first. If you don’t get the points, so be it. You go onto your second choice and so on. If you make a mistake in the order by which you select your courses, you may be stuck with a course you’d least prefer ahead of one you’d prefer. Unfortunately T.U.S., or any 3rd level educator cannot help you in this case.

If I pick a Level 6 or 7 course can I progress onto a higher level course ?

Yes, nearly all of our courses are designed with the ladder or opportunity in mind. This means that a student who passes a two year Level 6 course can go onto the 3rd year of Level 7 course (or into 3rd year of a Level 8) where a suitable one exists. Likewise a student who passes a three year level 7 course can go into the 4th year of a Level 8 course. Check the detail of each specific course on our website or prospectus to see the progression options.

What are the minimum entry requirements ?

For our Level 6 & 7 courses ;
A minimum of 5 O6/H7 grades in five Leaving Certificate subjects, including Mathematics and English or Irish.

For our Level 8 courses ;
A minimum of 2 H5 & 4 O6/H7 grades in six Leaving Certificate subjects, including English or Irish and a minimum of an O4 in Mathematics

What Leaving Cert subjects do I need to secure an engineering course ?
There are no mandatory subjects that you have to have for any of our engineering courses, apart from the generic minimum entry requirements as detailed above. You don't have to have engineering to study an engineering course here in T.U.S. However the majority of our students would have one or more of the following suitable subjects. It means there's a good chance that they can think and study like an engineer. Don't worry if you don't have some or any of these subjects. We won't assume you do in first year.

- Engineering
- Technology
- Design and Communication Graphics
- Physics
- Physics and Chemistry
- Construction Studies
- Agricultural Science
- Applied Mathematics

Do I need Higher level maths to enter an engineering course in TUS Midwest ?
No you don't. The majority of our first year students on any engineering course will have ordinary level maths. Most of our first years will start off feeling that they are not too confident in maths.

With so many courses (26) on offer how do I pick the right one ?
Keep on attending open days or marketing events in third level institutes and universities such as Engineering Week 2023. If you have a relation or friend who is or was on an engineering course, talk to

them about their experience. Get into the detail of the list of modules or subjects to learn the difference between each type of engineering course. Don't be lead by just the nice photo or video. If you can, visit an engineer at their workplace to see what it is they do as a career. Ask your guidance counsellor or teachers at school for advice. Read, watch relevant videos and be inquisitive.

8 TUS Midwest Engineering Courses

We have 26 engineering courses across three departments, at 4 different levels.

8.1 Department of the Built Environment

Course :	Built Environment (Common Entry)
Level :	8
Course Code :	US883
CAO Points :	334

Course :	Civil Engineering
Level :	7
Course Code :	US760
CAO Points :	243

Course :	Civil Engineering Management (Hons)
Level :	8
Course Code :	US886
CAO Points :	349

Course :	Construction Management (Hons)
Level :	8
Course Code :	US885
CAO Points :	280

8.2 Department of Electrical and Electronic Engineering

Course :	Electrician Apprenticeship
Level :	6 (Cert)
Course Code :	n/a
CAO Points :	n/a

Course :	Electrical Engineering
Level :	7
Course Code :	US750
CAO Points :	328

Course :	Electrical Engineering (Honours)
Level :	8
Course Code :	US900
CAO Points :	340

Course :	Electronic Engineering with Computer Systems
Level :	7
Course Code :	US751
CAO Points :	232

Course :	Electronic Engineering with Computer Systems (Honours)
Level :	8
Course Code :	US903
CAO Points :	311

Course :	Robotics and Automation Engineering
Level :	7
Course Code :	US753
CAO Points :	293

Course :	Robotics and Automation Engineering (Hons)
Level :	8
Course Code :	US902
CAO Points :	326

Course :	Renewable & Electrical Energy Engineering
Level :	7
Course Code :	US752
CAO Points :	290

Course :	Renewable & Electrical Energy Engineering (Hons)
Level :	8
Course Code :	US901
CAO Points :	336

8.3 Department of Mechanical and Automobile Engineering

Course :	MAMF (Fitter) Apprenticeship
Level :	6 (Cert)
Course Code :	n/a
CAO Points :	n/a

Course :	Motor Mechanic Apprenticeship
Level :	6 (Cert)
Course Code :	n/a
CAO Points :	n/a

Course :	Agricultural Mechanisation
Level :	6
Course Code :	US651
CAO Points :	224

Course :	Agricultural Engineering
Level :	7
Course Code :	US769
CAO Points :	New

Course :	Automobile Technology
Level :	6
Course Code :	US650
CAO Points :	301

Course :	Road Transport Technology and Management
Level :	7
Course Code :	US775
CAO Points :	311

Course :	Automotive Engineering & Transport Management
Level :	8
Course Code :	US915
CAO Points :	353

Course :	Engineering Technology Management
Level :	8
Course Code :	US909
CAO Points :	New

Course :	Mechanical Engineering
Level :	7
Course Code :	US771
CAO Points :	309

Course :	Mechanical Engineering
Level :	8
Course Code :	US911
CAO Points :	311

Course :	Precision Engineering
Level :	7
Course Code :	US774
CAO Points :	213

Course :	Precision Engineering
Level :	8
Course Code :	US914
CAO Points :	300

Course :	Process & Engineering Management (Hons)
Level :	8 (Add-on)
Course Code :	US914
CAO Points :	N/a

8.4 TUS Midlands Midwest 2024 Prospectus

A link to the full TUS Midlands and Midwest can be found at ;

https://tus.ie/undergrad/prospectus/

Scan here to view and download
the full TUS 2024 prospectus.

Thank you and the best of luck in your leaving cert exams in June and your continuing education in the third level sector.