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1. Outline the FOUR duties of workers as laid down in the Code of Safe Working Practices for Merchant Seamen. (10)

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2. With reference to the engine log books, explain the reasons for recording EACH of the following, and the effect on the engine should the temperatures be outside the normal parameters:

   (a) exhaust temperatures; (3)

   (b) cooling water inlet/outlet temperature; (3)

   (c) lubricating oil temperature. (4)

29 January 2021

3. (a) State the purpose of a planned maintenance system. (4)

   (b) State THREE parameters on which planned maintenance may be based. (3)

   (c) State how an approved planned maintenance system can influence classification society requirements. (3)

29 January 2021

4. With reference to the international agreement governing the discharge of oil from ships:

   (a) state the name of the International Authority responsible for overseeing the legislation; (1)

   (b) state the name of the appropriate regulation; (1)

   (c) state what the abbreviation SOPEP stands for; (2)

   (d) explain the purpose of a SOPEP; (2)

   (e) list FOUR items of information a SOPEP should contain. (4)

29 January 2021

5. (a) State the MARPOL Annex number which deals with the disposal of sewage. (1)

(b) With reference to the Annex stated in part (a), state the rules for EACH of the following:

(i) when the sewage is untreated; (2)

(ii) when the sewage is comminuted and disinfected. (2)

(c) Explain why the final discharge from an approved sewage treatment plant is chlorinated before discharge. (2)

(d) Explain how chlorination is carried out and monitored. (2)

(e) State the correct chlorine content of the final discharge. (1)

29 January 2021

6. (a) Sketch a vapour compression refrigeration system, labelling the main components. (5)

(b) Indicate the refrigerant conditions at the salient points on the sketch in part(a). (5)

29 January 2021

7. With reference to water treatment:

(a) state the treatment required for fresh water taken on from ashore; (2)

(b) state FOUR properties required for water used for domestic purposes, describing how this may be achieved in EACH case. (8)

29 January 2021

8. Explain EACH of the following types of motion:

(a) roll; (2)

(b) pitch; (2)

(c) yaw; (2)

(d) surge; (2)

(e) heave. (2)

29 January 2021

9. (a) Define EACH of the following:

   (i) Flash Point; (2)

   (ii) Ignition Point (2)

   (iii) Auto Ignition Temperature. (2)

   (b) Explain the requirements for the discharge of CO_2 of a machinery space fixed firefighting installation with regard to volume and time. (4)

29 January 2021

10. (a) State the meaning of EACH of the following terms in relation to a vessel's size:

    (i) gross tonnage; (2)

    (ii) net tonnage; (1)

    (iii) lightweight; (2)

    (iv) deadweight; (2)

    (v) displacement. (2)

    (b) State the relationship between Lightweight, Deadweight and Displacement. (1)

29 January 2021

1. Outline the FOUR duties of workers as laid down in the Code of Safe Working Practices for Merchant Seamen. (10)

The Code of Safe Working Practices for Merchant Seamen outlines several worker duties, but here are four key ones:

1. **Take Reasonable Care for Your Own Safety and Others:** This means being aware of your surroundings, following safety procedures, using personal protective equipment (PPE) properly, and

avoiding actions that could endanger yourself or others.

2. **Cooperate with Health and Safety Measures:** This includes complying with safety instructions, participating in safety drills, reporting hazards or unsafe work practices, and working collaboratively with colleagues and superiors to maintain a safe working environment.

3. **Report Identified Hazards and Deficiencies:** When you encounter a potential safety risk, damaged equipment, or malfunctioning systems, it's your duty to report them immediately to the appropriate officer or designated personnel. This allows for prompt corrective action and minimizes potential accidents.

4. **Proper Use of Equipment and Handling of Hazardous Materials:** Workers are responsible for using tools, machinery, and other equipment according to their designated purpose and following safe operating procedures. This also includes handling hazardous materials with due care, following established protocols, and wearing appropriate PPE when necessary.

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2. With reference to the engine log books, explain the reasons for recording EACH of the following, and the effect on the engine should the temperatures be outside the normal parameters:

(a) exhaust temperatures; (3)

(b) cooling water inlet/outlet temperature; (3)

(c) lubricating oil temperature. (4)

Engine Log Book Entries: Temperature Monitoring

Engine log books record various temperature readings to monitor engine health and performance. Here's a breakdown of why each temperature is recorded and the potential effects if they deviate from normal parameters:

(a) Exhaust Temperatures:

Reason for Recording: Exhaust gas temperature (EGT) is an indicator of engine combustion efficiency.

Effect of Abnormal Temperatures:

- **High EGT:** Can indicate several issues:
    - **Lean Burn:** Insufficient fuel can cause high EGT due to incomplete combustion. This can lead to increased engine wear, reduced power output, and potential exhaust valve damage.
    - **Faulty Injectors:** Clogged or malfunctioning injectors can cause uneven fuel distribution, leading to pockets of high temperature in the cylinders.
    - **Turbocharger Problems:** Issues with the turbocharger, such as restricted airflow or oil leaks, can contribute to high EGT.

- **Low EGT:** Less common, but a low EGT might indicate:
    - **Rich Burn:** Excessive fuel can cause incomplete combustion and lower EGT. This can lead to fuel inefficiency, increased smoke emissions, and potential fouling of spark plugs or injectors.
    - **Coolant System Issues:** A malfunctioning thermostat or coolant leak could cause the engine to run cooler than normal, leading to a lower EGT.

(b) Cooling Water Inlet/Outlet Temperature:

Reason for Recording: These readings monitor the effectiveness of the engine cooling system.

Effect of Abnormal Temperatures:

- **High Outlet Temperature:** Indicates the engine is running hotter than normal. This could be caused by:
    - **Low Coolant Level:** Insufficient coolant circulation due to a leak or low level can lead to overheating.
    - **Blocked Radiator/Heat Exchanger:** Restricted coolant flow due to clogged passages in the radiator or heat exchanger can cause overheating.
    - **Faulty Water Pump:** A malfunctioning water pump can reduce coolant circulation and lead to overheating.
- **Low Outlet Temperature:** Less common, but a low outlet temperature could indicate:
    - **Stuck-Open Thermostat:** A malfunctioning thermostat that remains stuck open allows excessive coolant flow, leading to overcooling and potentially longer engine warm-up times.

(c) Lubricating Oil Temperature:

Reason for Recording: Lubricating oil temperature is crucial for proper engine lubrication.

Effect of Abnormal Temperatures:

- **High Oil Temperature:** Can lead to:
    - **Oil Breakdown:** Excessive heat accelerates oil degradation, reducing its lubricating properties and increasing wear on engine components.
    - **Increased Oil Viscosity:** Hot oil becomes thinner, reducing its ability to provide adequate lubrication.
- **Low Oil Temperature:** Less common, but very cold oil can be:
    - **Too Thick:** Thick oil may not flow properly at startup, leading to increased friction and wear until the oil warms up.

By monitoring these engine temperatures and comparing them to normal operating ranges, engineers can identify potential problems early on. Taking corrective actions can prevent engine damage, maintain optimal performance, and ensure safe and reliable operation.

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3. (a) State the purpose of a planned maintenance system. (4)

(b) State THREE parameters on which planned maintenance may be based. (3)

(c) State how an approved planned maintenance system can influence classification society requirements. (3)

Planned Maintenance Systems and Classification Societies:

(a) Purpose of a Planned Maintenance System (PMS):

A Planned Maintenance System (PMS) is a proactive approach to maintaining equipment and assets. Its primary purpose is to:

- **Prevent Equipment Failures:** By scheduling regular maintenance tasks, the PMS aims to identify and address potential problems before they escalate into critical failures that can cause downtime, safety hazards, or costly repairs.
- **Optimize Equipment Performance:** Regular maintenance helps ensure equipment operates efficiently and within its designed parameters, leading to increased reliability, availability, and overall lifespan.
- **Reduce Maintenance Costs:** A PMS can help control maintenance costs by preventing major breakdowns and associated repair expenses. Predictive maintenance tasks can also help identify components nearing failure, allowing for cost-effective replacements before a complete breakdown occurs.
- **Improve Safety:** By proactively addressing equipment issues, a PMS can help create a safer working environment by minimizing the risk of accidents due to equipment malfunction.

(b) Parameters for Planned Maintenance:

Planned maintenance tasks can be scheduled based on various parameters, including:

- **Running Hours:** This is a common method for equipment with components that wear out over time. Maintenance is scheduled based on the number of hours the equipment has been operating. For example, engine oil changes might be scheduled every 500 running hours.
- **Operating Calendar:** Certain maintenance tasks might be time-based, regardless of usage. For example, annual inspections or filter replacements might be scheduled based on a calendar timeframe, ensuring preventive maintenance even for infrequently used equipment.
- **Condition Monitoring:** Modern PMS incorporate condition-based maintenance techniques that utilize sensors and data analysis to monitor equipment health. Maintenance tasks are then triggered based on actual equipment condition rather than predetermined intervals. This can optimize maintenance schedules and avoid unnecessary servicing.

(c) Influence of Approved PMS on Classification Societies:

Classification societies, like DNV or Lloyd's Register, are organizations that set standards for ship design, construction, and operation to ensure safety and environmental compliance. An approved Planned Maintenance System can positively influence classification society requirements in a few ways:

- **Reduced Survey Scope:** A well-documented and effectively implemented PMS demonstrates a commitment to proactive maintenance. This can lead to reduced scope during classification society surveys, as there's greater confidence in the vessel's overall condition.
- **Improved Operational Efficiency:** A functioning PMS can contribute to a vessel's operational efficiency by minimizing equipment downtime and ensuring regulatory compliance. This can be viewed favorably by classification societies.
- **Enhanced Safety Culture:** A strong PMS demonstrates a focus on preventative maintenance and safety, which aligns with the goals of classification societies.

Overall, an approved PMS can streamline interactions with classification societies, potentially reducing survey burdens and demonstrating a commitment to safe and reliable vessel operation.

Planned Maintenance Systems: Purpose, Parameters, and Classification Society Influence

(a) Purpose of a Planned Maintenance System (PMS):

A Planned Maintenance System (PMS) is a structured approach to maintaining equipment and machinery. Its primary purpose is to:

- **Prevent breakdowns:** By proactively scheduling maintenance tasks, a PMS aims to identify and address potential problems before they escalate into major failures.
- **Optimize equipment lifespan:** Regular and appropriate maintenance helps extend the operational life of machinery by minimizing wear and tear.
- **Enhance safety:** A well-maintained system reduces the risk of accidents and injuries associated with equipment malfunctions.
- **Improve efficiency:** Proper maintenance ensures equipment operates at optimal performance levels, leading to increased fuel efficiency and reduced emissions.
- **Reduce maintenance costs:** By preventing major breakdowns and extending equipment life, a PMS can help minimize overall maintenance expenditure.

(b) Parameters for Planned Maintenance:

Planned maintenance schedules are typically based on a combination of three key parameters:

1. **Manufacturer's recommendations:** Equipment manufacturers usually provide recommended maintenance intervals for specific components based on their design and expected lifespan.

2. **Operating hours/cycles:** Maintenance tasks are often scheduled based on the accumulated operating hours or number of cycles the equipment has undergone. This ensures critical components are serviced before they reach their wear limits.

3. **Condition monitoring:** Modern PMS may incorporate data from condition monitoring systems like vibration analysis or oil analysis. This allows for more tailored maintenance schedules based on the actual health and performance of the equipment.

(c) Influence of Approved PMS on Classification Societies:

Classification societies (CS) play a vital role in ensuring vessel safety and regulatory compliance. An approved Planned Maintenance System can positively influence a vessel's classification society requirements in several ways:

- **Demonstrates proactive approach:** A well-documented PMS demonstrates the owner's commitment to preventive maintenance and safety. This can lead to smoother inspections and potentially fewer deficiencies identified by CS surveyors.
- **Aligns with regulations:** Approved PMS are often designed to align with international maritime regulations and CS guidelines. This simplifies compliance efforts and reduces the risk of regulatory violations.
- **Reduces risk of breakdowns:** By minimizing breakdowns and equipment failures, an effective PMS lowers the chance of incidents that might require CS involvement or detain the vessel for repairs.
- **Provides operational data:** Record keeping within the PMS can provide valuable data on equipment performance and maintenance history. This data can be beneficial for CS surveyors in assessing the overall condition of the vessel and its machinery.

In essence, an approved Planned Maintenance System promotes a culture of safety and proactive maintenance, which aligns with the goals of classification societies. This can lead to a more streamlined classification process and contribute to the safe and reliable operation of the vessel.

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4. With reference to the international agreement governing the discharge of oil from ships:

(a) state the name of the International Authority responsible for overseeing the legislation; (1)

(b) state the name of the appropriate regulation; (1)

(c) state what the abbreviation SOPEP stands for; (2)

(d) explain the purpose of a SOPEP; (2)

(e) list FOUR items of information a SOPEP should contain. (4)

International Agreement on Oil Pollution and SOPEPs:

(a) International Authority:

The International Maritime Organization (IMO) is the international authority responsible for overseeing the legislation governing the discharge of oil from ships.

(b) Appropriate Regulation:

The key regulation addressing oil pollution prevention from ships is:

- **MARPOL Annex I: Regulations for the Prevention of Pollution by Oil**.

(c) SOPEP Abbreviation:

SOPEP stands for **Shipboard Oil Pollution Emergency Plan**.

(d) Purpose of a SOPEP:

A SOPEP is a mandatory document for all seagoing vessels of a certain size. It outlines the procedures and actions to be taken in the event of an oil spill at sea. The SOPEP serves as a crucial guide for the ship's crew to respond effectively and minimize the environmental impact of the spill.

(e) Four Items in a SOPEP:

1. **Reporting Procedures:** The SOPEP details the reporting requirements for oil spills to relevant authorities, including the coastal state, flag state, and the IMO.

2. **Oil Spill Response Equipment:** The plan inventories all onboard equipment and resources available for oil spill response, such as containment booms, skimmers, and dispersants.

3. **Spill Response Actions:** Detailed procedures are outlined for various oil spill scenarios, including deployment of response equipment, containment strategies, and cleanup methods.

4. **Training and Drills:** The SOPEP specifies training requirements for crew members in oil spill response procedures and conducting regular drills to ensure crew familiarity with the plan and proper equipment use.

By having a comprehensive and up-to-date SOPEP, ship crews are better prepared to handle oil spill emergencies effectively, reducing the risk of environmental damage and facilitating efficient response efforts.

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5. (a) State the MARPOL Annex number which deals with the disposal of sewage. (1)

(b) With reference to the Annex stated in part (a), state the rules for EACH of the following:

(i) when the sewage is untreated; (2)

(ii) when the sewage is comminuted and disinfected. (2)

(c) Explain why the final discharge from an approved sewage treatment plant is chlorinated before discharge. (2)

(d) Explain how chlorination is carried out and monitored. (2)

(e) State the correct chlorine content of the final discharge. (1)

MARPOL Annex and Sewage Disposal

(a) MARPOL Annex for Sewage Disposal:

The MARPOL Annex dealing with sewage disposal is **Annex IV - Regulations for the Prevention of Pollution by Sewage from Ships**.

(b) Sewage Discharge Rules:

(i) Untreated Sewage:

The general rule under MARPOL Annex IV is that the discharge of **untreated sewage** from ships is **prohibited**. Exceptions are allowed only in very specific circumstances, such as:

- **When the nearest land is more than 12 nautical miles away** (certain designated special areas may have stricter rules).
- **The ship is en route** and proceeding at a speed of not less than 4 knots.
- The sewage is not proveniente from spaces containing live animals or toilets used by passengers.

(ii) Comminuted and Disinfected Sewage:

The discharge of **comminuted and disinfected sewage** is allowed under certain conditions:

- The sewage must be **comminuted** (ground into small particles) to promote faster dispersal.
- It must be **disinfected** using an approved method (e.g., chemicals) to reduce harmful bacteria and viruses.
- The discharge can only occur **when the nearest land is more than 3 nautical miles away**.
- The ship must be en route and proceeding at a speed of not less than 4 knots.

(c) Chlorination of Final Discharge from Sewage Treatment Plant:

The final discharge from an **approved sewage treatment plant** onboard a ship may be chlorinated before discharge for several reasons:

- **Disinfection:** Chlorine is a powerful disinfectant that inactivates harmful bacteria and viruses present in treated sewage. This helps protect public health and the marine environment from potential pathogens.
- **Reduced Biological Oxygen Demand (BOD):** Chlorine can also help reduce the BOD of the treated sewage. BOD refers to the amount of oxygen required by microorganisms to decompose organic matter in the water. Lower BOD helps minimize oxygen depletion in the receiving water body, which is crucial for maintaining a healthy marine ecosystem.

(d) Chlorination Process and Monitoring:

- **Chlorination System:** Ships with approved sewage treatment plants typically employ an automated chlorination system. This system injects a measured amount of chlorine solution into the treated sewage effluent before discharge.
- **Monitoring:** The chlorine residual level in the final discharge is continuously monitored using chlorine residual analyzers. This ensures the appropriate level of disinfection is achieved without exceeding the permissible chlorine content limits.

(e) Correct Chlorine Content of Final Discharge:

The permissible chlorine content in the final discharge is strictly regulated by MARPOL Annex IV. The specific limits may vary depending on the discharge location and specific regulations. However, it is generally recommended to maintain a **low but measurable chlorine residual** in the treated effluent to ensure effective disinfection while minimizing environmental impact.

29 January 2021

6. (a) Sketch a vapour compression refrigeration system, labelling the main components. (5)

(b) Indicate the refrigerant conditions at the salient points on the sketch in part(a). (5)

Vapor Compression Refrigeration System

(a) Main Components:

A vapor compression refrigeration system is the most widely used method for air conditioning and refrigeration. It works by circulating a refrigerant through four main components:

1. **Compressor:** Acts as a pump, increasing the pressure and temperature of the refrigerant vapor.
2. **Condenser:** A heat exchanger where the high-pressure hot refrigerant vapor releases heat to the surrounding environment, typically air or water. This process condenses the refrigerant back into a liquid state.
3. **Expansion Valve (or Capillary Tube):** Also known as a throttle valve, this device reduces the pressure of the liquid refrigerant. This pressure reduction causes a drop in temperature.
4. **Evaporator:** Another heat exchanger where the low-pressure, cool liquid refrigerant absorbs heat from the space being cooled, causing it to evaporate (transform into a gas).

(b) Refrigerant Conditions:

- **Compressor Inlet:** Low pressure, low temperature (vapor)
- **Compressor Outlet:** High pressure, high temperature (vapor)
- **Condenser Outlet:** High pressure, moderate temperature (liquid)
- **Expansion Valve Outlet:** Low pressure, low temperature (liquid)
- **Evaporator Outlet:** Low pressure, low temperature (vapor)

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7. With reference to water treatment:

(a) state the treatment required for fresh water taken on from ashore; (2)

(b) state FOUR properties required for water used for domestic purposes, describing how this may be achieved in EACH case. (8)

Water Treatment: Onshore Intake and Domestic Properties

(a) Treatment for Onshore Fresh Water:

Depending on the source and local regulations, onshore fresh water might require minimal or additional treatment before being suitable for shipboard use:

- **Minimal Treatment:** If the source is a well-maintained municipal supply with established quality control, minimal disinfection with chlorine or UV light might be sufficient.
- **Additional Treatment:** If the source is unknown or of questionable quality, further treatment steps might be necessary:
    - **Filtration:** To remove suspended particles, turbidity, and any residual chlorine present in some municipal supplies.
    - **Reverse Osmosis (Optional):** If the water has high salinity or requires further reduction in dissolved minerals.
    - **Disinfection:** Ensuring proper disinfection with chlorine or UV light to eliminate any potential bacterial contamination.

The specific treatment steps will depend on the quality of the onshore water source and the ship's own treatment capabilities.

(b) Properties of Domestic Water and Treatment Methods:

1. **Microbiologically Safe:** The water must be free from harmful bacteria, viruses, and parasites that can cause waterborne diseases.
- **Treatment:** Disinfection with chlorine, UV light, or other approved methods to kill or inactivate microorganisms.
2. **Clear and Colorless:** The water should be visually appealing, free from turbidity, and have no noticeable color.
- **Treatment:** Filtration to remove suspended particles and organic matter that can cause cloudiness or color.
3. **Pleasant Taste and Odor:** The water should be palatable and free from objectionable tastes or odors.
- **Treatment:**
    - **Activated Carbon Filtration:** Absorbs chlorine, organic compounds, and other taste/odor causing substances.
    - **Aeration:** Can help remove volatile compounds that contribute to unpleasant odors.
    - **pH Adjustment:** Balancing the pH level (around 7.0-8.5) can improve taste.
4. **Low in Dissolved Minerals:** While some minerals are essential, excessively high levels can make the water taste salty or hard (causing scale buildup).
- **Treatment:**
    - **Reverse Osmosis (Optional):** For significant reduction in dissolved minerals, especially in cases of high salinity.
    - **Ion Exchange (Optional):** Can be used to selectively remove specific minerals like calcium and magnesium responsible for water hardness.

By implementing these treatment methods, shipboard water treatment systems can ensure that the water taken on board meets the necessary domestic water quality standards.

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8. Explain EACH of the following types of motion:

(a) roll; (2)

(b) pitch; (2)

(c) yaw; (2)

(d) surge; (2)

(e) heave. (2)

A ship experiences six main types of motion as it travels through water. Here's a breakdown of each:

(a) **Roll:** Roll is a rotational motion where the vessel tilts from side to side about its longitudinal axis. Imagine a seesaw pivoting in the center. Roll motion can be caused by wave action or uneven cargo distribution. Excessive rolling can be uncomfortable for passengers and can affect cargo stability.

(b) **Pitch:** Pitch is a rotational motion where the vessel bobs up and down about its transverse axis. Imagine a seesaw pivoting at the ends. Pitching motion is caused by encountering waves. The bow rises and falls as it encounters wave crests and troughs.

(c) **Yaw:** Yaw is a rotational motion where the vessel turns about its vertical axis. Imagine a spinning top. Yawing motion is caused by rudder movement or external forces like wind or current. It's the primary way a ship changes direction.

(d) **Surge:** Surge is a linear motion where the entire vessel moves forwards or backwards along its longitudinal axis. Imagine a car moving forward or backward in a straight line. Surge is primarily caused by the propeller thrust or external forces like wind or current.

(e) **Heave:** Heave is a linear motion where the entire vessel moves vertically up and down. Imagine a bobbing cork. Heave motion is caused by waves lifting and lowering the entire vessel. Heave can be particularly noticeable in heavy seas.

29 January 2021

9. (a) Define EACH of the following:

   (i) Flash Point; (2)

   (ii) Ignition Point (2)

   (iii) Auto Ignition Temperature. (2)

   (b) Explain the requirements for the discharge of CO_2 of a machinery space fixed firefighting installation with regard to volume and time. (4)

(a) Engine Room Fire Main Isolation Valve

- **Need:** Isolates the fire main within the engine room in case of a fire. This allows firefighters to:
  - Maintain firefighting capabilities in other areas using water from auxiliary pumps.
  - Minimize water damage in other compartments if a fire main pipe ruptures.
- **Location:** Outside the engine room in a readily accessible and tenable position.
- **Operation:** Manually operated (handwheel or lever) to shut off water flow to the engine room section. May also have remote operation capability.

(b) Valve Type:

- **Gate Valve:** Provides positive shutoff, durability, and a relatively simple design for easy operation and maintenance.

(c) Sprinkler Head Construction

- **Frame:** Houses internal components and connects to piping.
- **Sealing Element:** Heat-sensitive element (glass bulb with liquid or bi-metallic strip) that keeps the opening sealed.

- **Deflector:** Distributes discharged water in a spray pattern.
- **Sprinkler (Optional):** May provide a pre-discharge misting effect.

I hope this summary is helpful! If you have any further questions or require explanations for different fire safety components, feel free to ask.

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10. (a) State the meaning of EACH of the following terms in relation to a vessel's size:

(i) gross tonnage; (2)

(ii) net tonnage; (1)

(iii) lightweight; (2)

(iv) deadweight; (2)

(v) displacement. (2)

(b) State the relationship between Lightweight, Deadweight and Displacement. (1)

Vessel Size Terminology:

(a) Here's a breakdown of the terms related to a vessel's size:

(i) **Gross Tonnage (GT):** This is a dimensionless unit that represents the total enclosed volume of a vessel. It's calculated based on a formula that considers the volume of all permanent enclosed spaces of the ship in cubic feet, divided by 100. While not a measure of weight, it provides a general indication of a vessel's overall size.

(ii) **Net Tonnage (NT):** This is another dimensionless unit derived from the gross tonnage. It represents the usable cargo space within the vessel, after accounting for areas dedicated to crew accommodation, machinery spaces, navigation, and propulsion. A larger difference between GT and NT indicates a higher proportion of space dedicated to cargo.

(iii) **Lightweight (LW):** This refers to the weight of the vessel itself, excluding cargo, fuel, passengers, crew, and any stores or provisions onboard. It includes the weight of the hull, superstructure, machinery, equipment, and permanent fixtures.

(iv) **Deadweight (DWT):** This is the weight carrying capacity of a vessel. It's calculated by subtracting the lightweight from the displacement. In simpler terms, it's the maximum weight of cargo, fuel, passengers, crew, and stores that a vessel can safely carry.

(v) **Displacement (DIS):** This refers to the total weight of water displaced by the vessel when floating at a specific trim and draft. In simpler terms, it's the weight of water the vessel pushes aside to float. Displacement is equal to the total weight of the vessel (lightweight) plus the weight of everything onboard (cargo, fuel, passengers, crew, and stores).

(b) Relationship Between Lightweight, Deadweight, and Displacement:

These terms are interrelated and form a critical equation for understanding a vessel's weight and carrying capacity:

Displacement (DIS) = Lightweight (LW) + Deadweight (DWT)

- **Displacement:** Represents the total weight of the vessel and everything onboard.
- **Lightweight:** The weight of the empty vessel itself.
- **Deadweight:** The maximum weight the vessel can carry (cargo, fuel, etc.).

Knowing a vessel's displacement and lightweight allows you to calculate its deadweight capacity. This information is crucial for loading cargo safely and ensuring the vessel remains within its operational limits.