DIRECTORATE OF MERCHANT SHIPPING
GOVERNMENT OF SRI LANKA
CERTIFICATE OF COMPETENCY EXAMINATION

GRADE : CHIEF MATE ON SHIPS OF 500 GT OR MORE (UNLIMITED)
SUBJECT : SHIP BOARD OPERATIONS
DATE : 22/04/2024

Time allowed THREE hours	Total marks : 180
ANSWER ALL QUESTIONS	Pass marks : 60%

Formulae and all intermediate steps taken in reaching your answer should be clearly shown. You may draw sketches wherever required. Electronic devices capable of storing and retrieving are **not** allowed.

1) Answer the following questions with regard to tanker cargo operations:

   a) Explain the following,
      i) Lower Flammable Limit
      ii) Upper flammable limit
      iii) Flash point

   (05 marks each)

   b) Describe why any liquid cargo is not filled to 100% of the tank capacity for normal carriage by sea.

   (05 marks)

   c) A tanker loads 3200 MT of crude oil at 30^0 C and SG of 0.8942. What would be the change in Ullage at discharge port where the temperature is 15^0 C and SG of 0.8959? Consider a change of 3 m^3 by volume corresponds to a change of 0.1 cm in Ullage as per calibration tables.

   (10 marks)

2) With reference to grain regulations explain,

   a) what is the minimum criterion to comply for a vessel to set out to sea with a consignment of grain?

   (10 marks)

   b) how the heeling arm due to grain shift is derived and what are the parameters for the vessel to remain seaworthy?

   (10 marks)

   c) what actions you could take to improve the situation if the vessel is found not complying with the requirements?

   (10 marks)

3) You are chief officer on a multi-purpose container vessel trading between Europe and South Africa.

a) Describe what precautions the vessel shall take while discharging machinery space bilges when in special areas and when in out-side of special areas.

(10 marks)

b) On the above-mentioned vessel how do you comply with MARPOL Annex V requirement in special areas and outside special areas.

(10 marks)

c) List the special areas as per MARPOL Annex – I

(10 marks)

4) Answer the following questions with regard to corrosion and painting:

a) Due to the operational environments, vessels are subjected to corrosion and deterioration. Various effective measures are being taken to minimize corrosion process on merchant vessels. Explain in detail these corrosion control methods used onboard a ship.

(10 marks)

b) Merchant ships are protected from environmental deterioration by various means like painting etc. Explain in detail main protections offered by marine paints.

(10 marks)

c) Calculate paint and thinner requirement for painting 5 cargo hold hatch covers if following information provided.

(10 marks)

Surface area of one hatch cover	= 380m2
Required DFT	= 125Microns
Volume of Solids	= 42%
Thinning requirement	=10%

5) Answer the following questions with regard to carriage of timber cargoes on deck:

a) A vessel loaded with timber deck cargo from Baltic to US experienced a considerable list during the voyage. When the vessel departed the loading port vessel left with an upright condition and experienced severe weather during the voyage. Explain in detail your investigation procedure and the actions taken to according to your identified situations.

(15 marks)

b) In order to maintain sufficient stability throughout the voyage on timber deck cargo vessels it is required to have substantial knowledge at the planning stage of the particular loading condition. Explain in detail main factors effecting change of displacement on a timber deck cargo vessel including mitigating actions required to compensate such situations.

(10 marks)

c) There are many concerns relating to the height of timber deck cargoes. Explain under what situations you will restrict the height of timber deck cargoes.

(05 marks)

6) Answer the following questions with regard to cargo care and ship's stability:

a) A comprehensive cargo plan will greatly eliminate delays and other cargo related claims. Explain what details should contain in a ship's cargo plan.

(08 marks)

b) Ship shore safety check list is becoming very common on many of merchant shipping trades. Explain the significance of "Ship Shore Safety Checklist" and state the basic contents of a ship shore safety check list.

(07 marks)

c) Vessel's freeboard is one of the main concerns during navigation and at ports. There are many importance of vessel's freeboard and this may vary according to application. Explain with a suitable statical stability curve the effect of change in freeboard for a vessel with constant beam, draught and KG including causes for the changes in freeboard.

(15 marks)

Answer Q 1

a)

- **Flash point;** The lowest temperature at which a liquid gives off sufficient gas to form a flammable gas mixture near the surface of the liquid. It will give a momentarily flash with external spark or ignition. But will not propagate fire
- **Upper Flammable Limit;** It is the concentration of hydrocarbon gas in the air above which there is insufficient air to support and propagate combustion.
- **Lower Flammable Limit; It is the** concentration of hydrocarbon gases in air below which there is insufficient hydrocarbon gases to support and propagate combustion

b) Tanks are not loaded to 100% of capacity due to following reasons

To prevent stresses of the tank if filled as the pressure exceed due to compression

To prevent spillage and to comply with MARPOL annex 1

In case of the crack of the tank due to 100%, there will be heavy oil spillage.

To comply with ISGOT manual and IOCC guidelines.

To comply with Vessel SMS as per the ISM code.

C) Total tonnage loaded at 30 C = 3200 MT
SG at 30 c = 0.8942
Total volume at 30c = 3200/0.8942 m3 = 3578.618 m3

SG at 15c in Discharging port= 0.8959
Total volume at the discharge =0. 3200/0.8959 = 3571.827 m3
Change of Volume = 3578.618- 3571.827= 6.791 m3
For 3 m3 ullage change = 0.1 cm
For 6.791 m3 ullage change = 0.1/3 X 6.791 = 0.226 cm

Answer Q 2

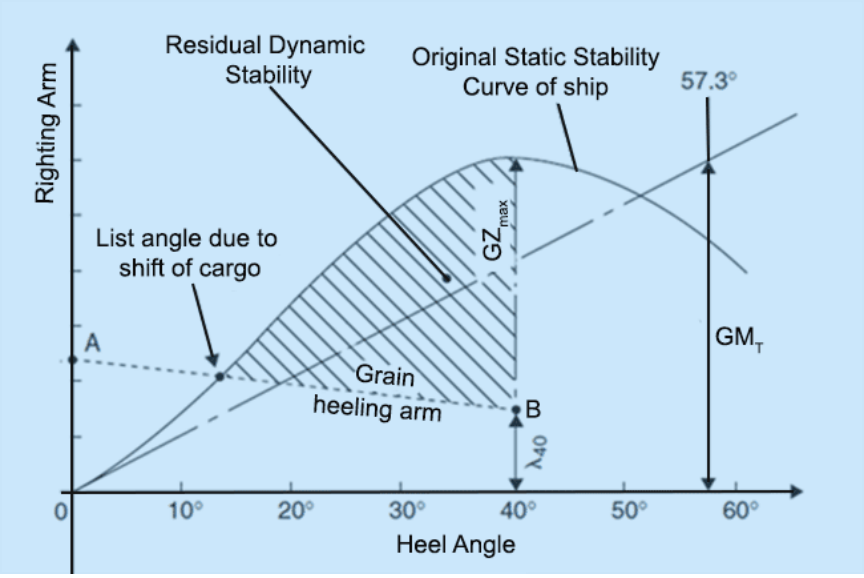
I. The angle of heel due to shift of grain shall not be greater than 12° or for ships of constructed on or after 1st January 1994 the angle at which the deck edge is immersed, whichever is the lesser.

II. In the statical stability diagram, the net or residual area between the heeling arm curve and the righting arm curve up to the angle of heel of maximum difference

between the ordinates of the two curves, or 40° or the angle of flooding, whichever is the least, shall in all conditions of loading be not less than 0.075 m/radians

III. The initial GM shall not be less than 0.30m, after correction for the FSC.

IV. Vessel should be up right before proceeding to sea.



b) how the heeling arm due to grain shift is derived and what are the parameters for the vessel to remain seaworthy?

(**10 marks**)

To derive heeling arm curve following information requires

- # Final displacement after loading
- # Proposed loading condition, the mount of cargo to be load in each hold.
- # Final KG
- # VHM- total volumetric heeling moment.
- # Stowage factor.

Procedure:

Find the GZ values for angle of heel from 0° to 70° (GZ=KN-KG Sinθ) from KN curves.

Using GZ as Y axis and angle of heel as X axis, draw statical stability diagram. Which indicate righting arm curve of the vessel for the proposed loading condition.

Using grain loading manual, find transverse VHM for each fully and partly loaded compartment. And add all to get total VHM.

Divide total VHM by SF (stowage factor) to obtain grain heeling moment.

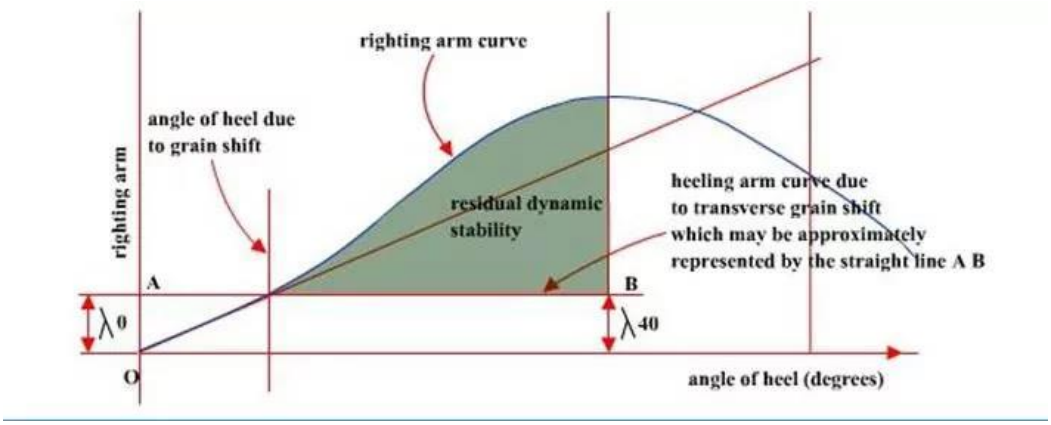
Total grain heeling moment divide by displacement to obtain $\lambda 0$

Now find $\lambda 40$, $\lambda 40 = \lambda 0 \times \text{Cos}\theta$ ($\theta = 40°$)

Mark $\lambda 0$, at the Y axis and $\lambda 40$ on Y axis at 40° heel. By joining two position and the line indicate heeling arm curve.

$$\text{Grain heeling moment} = \frac{\text{Total volumetric heeling moment}}{\text{Stowage factor}}$$

$$\lambda 0 = \frac{\text{Grain heeling moment}}{\text{Displacement}}$$



c) what actions you could take to improve the situation if the vessel is found not complying with the requirements?

(10 marks)

1. Intake ballast in bottom tanks to improve GM, if it's complied with load line regulation requirement throughout the voyage and draft requirement departure / arrival ports.
2. Reduce free surface effect.
3. Following are recommended methods for securing grain as per international grain code for filled and partly filled compartments.
   # Shifting Boards (Filled / Partly Filled Compartment)
   # Saucers (Filled Compartment)

Bundling of Grain (Filled Compartment)
Over stowing Arrangements (Partly Filled Compartment)
Strapping or Lashing (Partly Filled Compartment)
Securing with Wire Mesh (Partly Filled Compartment)

3) You are chief officer on a multi-purpose container vessel trading between Europe and South Africa.

a) Describe what precautions the vessel shall take while discharging machinery space bilges when in special areas and when in out-side of special areas.
(10 marks)

All discharges to sea are regulated under MARPOL and therefore the discharge criteria must be complied with. For machinery space bilges, discharge criteria are given under Annex I of MARPOL.

- Outside special areas except Arctic Region.
  - Ship shall be enroute proceeding.
  - Oily mixture shall be processed through an approved oil filtering equipment.
  - Oil content shall not be more than 15ppm without dilution.
  - Oily mixture shall not be originated from cargo pump room bilges. (For tankers)
  - Not mixed with cargo residues. (For tankers)
- Inside special areas
  - Ship shall be enroute proceeding.
  - Oily mixture shall be processed through an approved oil filtering equipment fitted with an alarm and automatic stopping device if oil content exceeds 15ppm.
  - Oil content shall not be more than 15ppm without dilution.
  - Any oil or oily mixtures discharge from any ship is prohibited within Antarctic Region.
  - Oily mixture shall not be originated from cargo pump room bilges. (For tankers)
  - Not mixed with cargo residues. (For tankers)

With all these criteria in compliance;

- Additional restrictions – National and local regulations must be considered prior discharging and more stringent criteria must be complied.
- There should not be any visible traces of oil on the surrounding waters and ship's wake after discharging.

- All discharges must be recorded in Oil Record Book Part I and counter signed by responsible officer and Master.

3b) On the above-mentioned vessel how do you comply with MARPOL Annex V requirement in special areas and outside special areas.
(10 marks)

In both scenarios (inside special areas and outside special areas), the vessel must be enroute while discharging any of the permitted garbage.

Type of garbage	Outside special areas	Inside special areas
Food waste (comminuted or grounded)	Discharge permitted more than 3nm from nearest land	Discharge permitted more than 12nm from nearest land/ice shelf
Food waste (not comminuted or grounded)	Discharge permitted more than 12nm from nearest land	Prohibited
Cargo residues contained in wash water (not harmful to marine environment)	Discharge permitted more than 12nm from nearest land	Discharge permitted more than 12nm from nearest land only if; - Both departure and arrival ports are with special area and vessel do not transit outside special area - No adequate reception facility in both ports.
Cargo residues not contained in wash water (not harmful to marine environment)	Discharge permitted more than 12nm from nearest land	Prohibited
Cleaning agents and additives contained in cargo hold wash water (not harmful to marine environment)	Discharge Permitted	Discharge permitted more than 12nm from nearest land
Cleaning agents and additives contained in external surface wash water (not harmful to marine environment)	Discharge Permitted	Discharge Permitted
Animal carcasses	Discharge Permitted – As far as possible from nearest land	Prohibited
Any other type of garbage / Plastic / Synthetic ropes / Incineration ash / Fishing gear	Prohibited	Prohibited

3c) List are the special areas as per MARPOL Annex – I (10 marks)

- Mediterranean Sea
- Baltic Sea
- Black Sea
- Red Sea
- Gulf Area
- Gulf of Aden
- Oman area of the Arabian Sea
- NW European Waters
- Antarctic Area
- Southern South African Waters

4 Answer the following questions with regard to corrosion and painting:

a) Due to the operational environments, vessels are subjected to corrosion and deterioration. Various effective measures are being taken to minimize corrosion process on merchant vessels. Explain in detail these corrosion control methods used onboard a ship.

(10 marks)

Answer 4a

Depending on the exposed environmental conditions and the accessibility for maintenance and inspections, different methods of corrosion protection are used for different areas of a ship.

Protective coating is a method of establishing a physical barrier between the bare metal and corrosion supportive factors. (air and water molecules) Painting, applying grease and also covering up with vinyl coatings or tapes are considered as coatings.

Different areas of the vessel are painted with different types of pain suited to those areas. Submerged hull area, rudder, bow thruster compartment are coated with special kind of anti-fouling paints while ballast tanks, fuel tanks and fresh water tanks are coated with different types of epoxy paints withstanding the contents inside tanks.

Use of alloys and dissimilar non corrosive materials is also a corrosion preventive method. The propeller, impellers of pumps, bow thruster are made of alloys which are non-corrosive.

Another method used to prevent corrosion is cathodic protection. This method is used on areas exposed to salt water which acts as the electrolyte in completing the corrosion reaction. Cathodic protection is done in two methods; sacrificial anodes system and impressed current cathodic protection (ICCP) system.

Inside the ballast tanks and the complex hull area near the propeller are covered with sacrificial anodes. These are usually zinc, zinc chromate or lead anodes which acts as the anode giving out electrons and protecting the ship's structures making them the cathode. These are periodically inspected and replaced as they are worn out.

The outer hull area is protected by ICCP system onboard. This is by continuous monitoring of the voltage difference relative to a reference cell mounted externally. The reference cell is usually of Ag or AgCl and doesn't erode.

The voltage is measured and provided to a control panel and the panel sends out a AC current to the hull structure which is equal and opposite to the reference cell. Thereby the vessel's hull is made to be the cathode always. This process provides protection against corrosion and the system can be monitored and adjusted. This system can only be operated in salt water.

All above are included in the PMS of a vessel as these should be carried out periodically in a well-planned manner to avoid any place or structure gone unnoticed. Planned inspections are carried out to identify pre corrosion indications and remedies are carried out. De-rusting, scaling and anti-corrosion chemical washing are done as protective measures.

4b) Merchant ships are protected from environmental deterioration by various means like painting etc. Explain in detail main protections offered by marine paints.
(10 marks)

Answer 4b

Marine paints provide protection to the metal structures in many ways.

Mainly marine paints are applied in several coats in order to create a physical barrier on metal surfaces not allowing water or air to contact. Thereby oxidation process is disrupted. Type of paints used differ as per the exposed environment.

Ship's areas below water line are coated with anti-fouling paints. These paints are specially applied with multi purposes. Main purpose being corrosion protection it also provides resistance against marine growth on the hull. The chemicals contained in these paints acts against sea creatures and growth on hull. It also carries self-polishing property thereby provides less friction to improve fuel efficiency of the vessel.

Cargo compartments specially in tankers are coated with special types of epoxy paints. Other than corrosion protection, the paints provide a good durability against high pressure washing. Also, these paints are non-reactive with the cargoes carried and able to withstand extreme variations in temperature so that cargo contamination is avoided. Also this saves time when preparing the cargo compartments to carry different cargoes.

The machinery spaces and the machineries themselves are coated with marine paints which are resistant to heat exposure. These paints will remain intact even when exposed to high temperatures. These provides protection to machinery parts and prevents corrosion.

Some paints consist of anodic pigments such as zinc, aluminum, lead and other galvanic pigments which acts as anodic particles sacrificing to protect the metal surfaces. Primer paints consisting of these pigments provide additional benefit of proper attachment onto surfaces. Thereby the lifetime of paint coat is extended.

In order to achieve the desired protection means, all paints must be applied in accordance with the maker's instructions. All ships have a plan indicating the type of paint to use for each section of the vessel. These include the amount and type of thinners and curing agents to be used.

These guidelines must be followed and proper surface preparation together with proper application will give the best output.

4c) Calculate paint and thinner requirement for painting 5 cargo hold hatch covers if following information provided.
(10 marks)

Surface area of one hatch cover = 380m2

Required DFT = 125Microns

Volume of Solids = 42%

Thinning requirement =10%

Answer 4c

Area of coating = 5 x 380m^2 = 1900m^2

$$TSR = \frac{SVR \times 10}{DFT}$$

$$TSR = \frac{42 \times 10}{125}$$

TSR = 3.36m^2L^{-1}

Theoretical Paint Consumption = Area / TSR

= 1900 m^2 / 3.36m^2L^{-1}

= 565.48 L

Thinner requirement = 565.48 x 10% = 56.5 L

05) Answer the following questions with regard to carriage of timber cargoes on deck:

(05 A vessel loaded with timber deck cargo from Baltic to US experienced a considerable list during the voyage. When the vessel departed the loading port vessel left with an upright condition and experienced severe weather during the voyage. Explain in detail your investigation procedure and the actions taken to according to your identified situations.

(15 marks)

If the vessel encounters list during the voyage, it is essential to find out the reason causing the list and also to consider if the vessel has lost her positive stability and reached an angle of loll. Prior taking any corrective actions, the stability condition of the vessel must be re assessed.

Initially it is most important to calculate the rolling period of the vessel. It must be calculated with visual observations to the best in order to determine if the vessel has lost her stability. If the rolling period has increased, there is a loss of GM and vice versa. If it is probable that the vessel's GM has diminished to zero or below, immediate actions must be taken to bring down the COG.

This can be achieved by sequential ballasting of bottom most tanks. Considerations must be given for load line limitations and vessel's stress limits.

By visual observations, it can be clarified if the list is caused due to beam winds.

Also, it is evident if ice accretion on top of the timber cargoes on deck. Ice accretion on top can accumulate more weight on the upper region bringing the COG up causing loss of GM.

If the vessel had been experiencing sea spray for a long period from the same side, water absorption on timber cargo can be suspected for that side of the vessel.

If the vessel experienced rain, water absorption can again be considered. Also check the water drains for any blockages. Green seas or rain water collected in the broken spaces may have caused list.

Carry out a physical check on the cargo if cargo securing has been loosened or any cargo shift has occurred.

Take soundings of all tanks including ballast tanks, fresh water tanks, fuel tanks, cofferdams, void spaces and bilges.

If any unexpected observations made, investigate on the same. Water ingress must also be considered from a leaking pipeline or failure of valve. Therefore, a thorough visual inspection must be carried out in each space.

Once the reason is found, assess the stability of the vessel with the changes and determine state of stability. Accordingly, counter actions can be done to correct the list by;

- Transfer of ballast water or fuel.
- Ballasting on the opposite side or de-ballasting from the same side.

Prior any of the above, load line limitations, vessel's stress limits, visibility criteria must be considered.

(06 In order to maintain sufficient stability throughout the voyage on timber deck cargo vessels it is required to have substantial knowledge at the planning stage of the particular loading condition. Explain in detail main factors effecting change of displacement on a timber deck cargo vessel including mitigating actions required to compensate such situations.

(10 marks)

When carrying timber cargo on deck, the displacement can be affected by below factors;

- Water absorption on deck cargo
- Ice accretion on deck cargo
- Weight of water accumulated in broken spaces.

Timber cargoes on deck are exposed to rain, sea spray and high seas. So, water absorption into timber must be considered as the GM will reduce. 10% of cargo weight must be allowed for water absorption and checked for arrival condition of the vessel as per timber code. The percentage values change as per the class of timber carried. Percentages are specified in the Timber Code.

An allowance of 30kgm^{-2} must be allowed for ice accretion on top of timber on deck when a vessel is trading in seasonal winter zones. Ice accretion on top of cargo can increase the displacement and cause reduction of GM as COG is moved up.

When timber cargo are loaded on deck, sufficient provisions must be made for the rain water or sea spray to drain out into sea without being trapped in between the broken spaces. Water being trapped within broken spaces can cause changes in the displacement.

Above considerations must be allowed and checked for the stability condition as well as the load line limitations in order to avoid any danger or non-compliance.

(07 There are many concerns relating to the height of timber deck cargoes. Explain under what situations you will restrict the height of timber deck cargoes.
(05 marks)

The height of timber deck cargo must be so as to;

- Comply with IMO visibility criteria.
- Not exceed the permissible load on deck and its components.
- Not exceed the lashing stresses and torsional stresses.
- Not to have any overhanging shoulders facing head seas.
- Have sufficient safe margin of stability throughout all stages of the passage.

Additionally, the height of timber cargo shall not exceed 1/3rd of extreme breadth of the vessel when trading in any seasonal winter zones in winter.

6 Answer the following questions with regard to cargo care and ship's stability:

d) **A comprehensive cargo plan will greatly eliminate delays and other cargo related claims. Explain what details should contain in a ship's cargo plan.**
(08 marks)

A cargo stowage plan is developed by the Chief Officer and agreed with the terminal and utilized by the officers in order to achieve a cost effective and efficient cargo stowage. The plan contains below information;

- Ship's name, Port of loading / discharging, Name of the terminal, Voyage number, Total volume available for loading.
- Arrival drafts and departure drafts of the vessel.
- Important hydrostatic information such as trim and list.
- Shows a clear picture of the stowage location of each cargo, container or the bulk cargoes with assigned colors and symbols for easy identification. A legend is provided in order to identify the colors and symbols.
- Total quantity of cargo to be loaded / discharged.
- Description of cargo – Dimensions, type of cargo (pallets, bale or packages)
- Quantity of cargo to be loaded in each cargo hold, on hatch or in bay wise in container vessels.
- List of special cargoes such as IMDG, reefer cargo, Out of gauge cargo.
- Available cargo gear and SWL.
- Lashing and securing arrangements for cargo units including any special arrangements.
- Chief officer's signature with date.

6b) Ship shore safety check list is becoming very common on many of merchant shipping trades. Explain the significance of "Ship Shore Safety Checklist" and state the basic contents of a ship shore safety check list.

(07 marks)

Ship-shore safety checklist has become mandatory under BLU code for bulk carrier operations in order to provide and agree upon all the safety concerns during an operation. Both parties (i.e., Ship and the Terminal) convey the information and safety procedures to be followed during the operation. This has helped to eliminate the accidents, over carriage of cargo, time delays and mostly the mis communication between the vessel and the terminal.

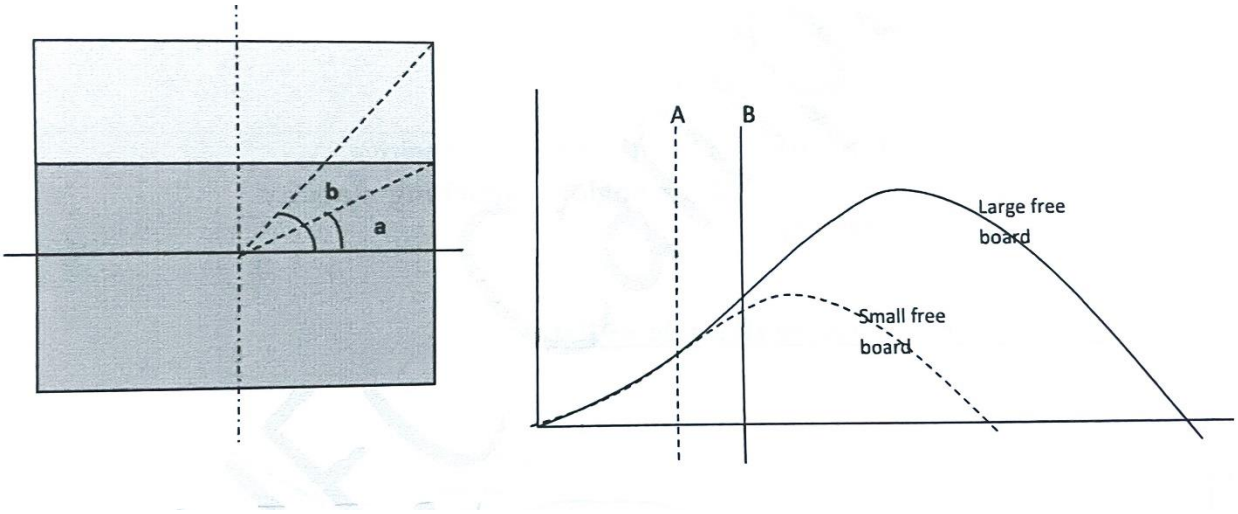
Both parties must fill up and sign in agreement to the checklist prior carrying out any cargo operation. The checklist includes following information;

- Ship's name, arrival date, name of the port and terminal, voyage number, name of the Master.
- Details of the terminal – Terminal name, responsible person and contact details.
- Vessel's maximum safe drafts, air draft on arrival and on departure.
- Minimum depth and maximum air clearance at the terminal.
- Safe means of access to the vessel must be clearly declared.
- Primary and backup means of communication between the vessel and the terminal.
- Emergency stop signals for cargo operation.
- Total quantity of cargo to be loaded / discharged.
- Rate of loading, sequence, minimum number of pours and the requirements for trimming.

- The vessel should declare maximum rate of ballasting / deballasting.
- Maximum allowable trim and list.
- Emergency contact details of shore authorities for any emergency onboard.
- Procedure for reporting and recording of any damages to vessel or cargo.
- Any special requirements or regulations of the terminal or port.
- Any other activities performed on the vessel. Such as bunkering, replenishing of stores or fresh water, main engine immobilization, hot work.
- Date, time and signature of the Master and the Terminal representative.

6c) Vessel's freeboard is one of the main concerns during navigation and at ports. There are many importance of vessel's freeboard and this may vary according to application. Explain with a suitable statical stability curve the effect of change in freeboard for a vessel with constant beam, draught and KG including causes for the changes in freeboard.

(15 marks)



- When the beam, draught and KG are constant, the initial statical GM will be same for the vessel. As the freeboard differs, angle of deck edge immersion (DEI) changes as shown in figure (a>b).
- In the statical stability curve, there is no change in GZ until the DEI of angle 'a'. But after angle 'a', the vessel with less freeboard has a decrease in the rate of increase of GZ where the vessel with higher freeboard shows improving statical stability until DEI angle 'b'. Thus, the area under the curve of 'b' is higher than that of 'a'. Which indicates that a vessel with higher freeboard possess a higher stability than a vessel with lower freeboard.

Causes for changes in freeboard

- Ship’s construction or the design.
- Assigned summer freeboard under load line certificate.
- Displacement of the vessel.
- Density of the water which the vessel floats.
- Trim of the vessel.