MT2003 MARITIME TECHNOLOGY AY1819 S1
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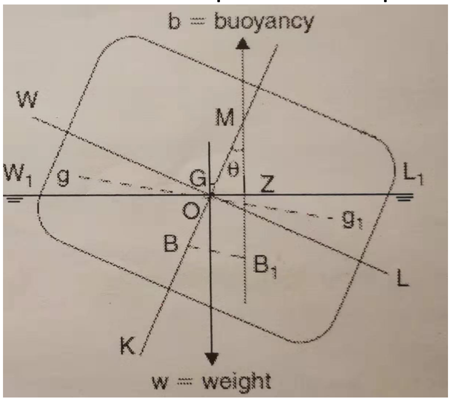
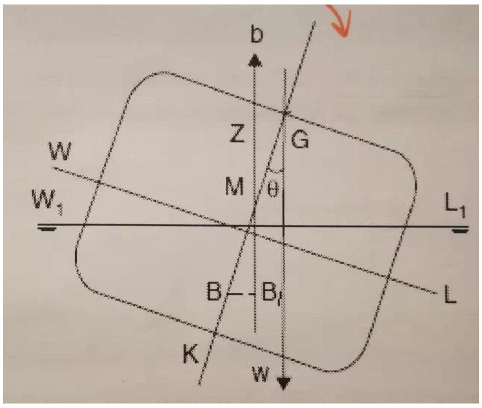
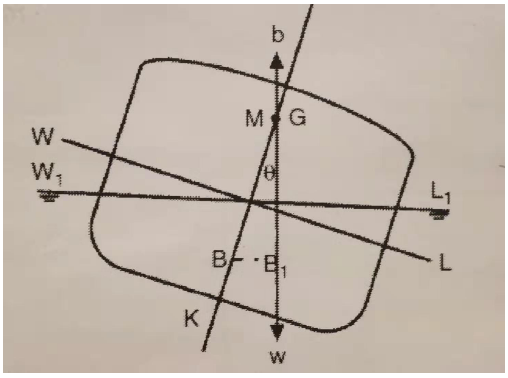
Q1
(a)
A ship is in stable equilibrium if, when heeled by an external force to a small angle, it returns to the upright when the force is removed. Ship in stable equilibrium has GM>0.



(b)
A ship is in unstable equilibrium if, when heeled by an external force to a small angle, it continues to heel further when the force is removed. GZ becomes capsizing lever. GM<0.



(c)
A ship is in neutral equilibrium if, when heeled by an external force, it comes to rest at an indeterminate angle of heel within small angles. GZ remains at 0 within small angles of heel. GM=0.



(d)
A ship in unstable or neutral equilibrium can be corrected by:

1) Shifting weight already on the ship to lower positions;

2) Loading weight below the center of gravity of the ship;
3) Discharging weight from positions above the center of gravity;
4) Removing free surfaces.

Q2

(a)

Inclining experiment:

The purpose of inclining experiment is to determine the position of G at light condition (ie. KG). The experiment is carried out by the builders when the ship is at or near completion as possible; that is as near as possible to the light condition as possible.

The ship is forcibly inclined by shifting weights a fixed distance across the deck. The weights used are usually concrete blocks, and the inclination is measured by the movement of plumb lines across specially constructed battens which lie perfectly horizontal when the ship is upright.

Usually two or three plumb lines are used and each is attached at the center line of the ship at a height of about 10m above the batten. If two lines are used then one is placed forward and the other aft. If a third line is used it is usually placed amidships.

Conditions:

Precautions prior to the experiment:

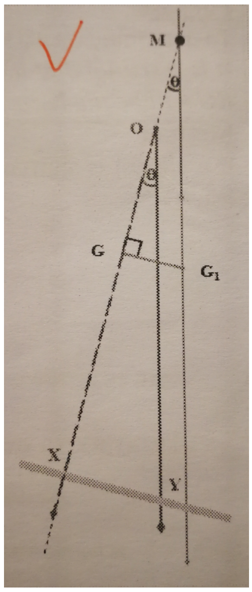
1) ship to be upright (no list);
2) moorings slack and gangway landed;
3) no significant wind, especially on the beam;
4) no significant tide;
5) derricks, crane etc. secured in normal sea-going position;
6) minimize free surfaces, tanks ideally should be full or empty.

Precautions to ensure accuracy of calculation:

1) ship's displacement to be determined accurately:
   (a) draughts to be read forward, aft and amidships on both sides;
   (b) end draughts to be corrected to the forward and aft perpendiculars (to ensure) evenkeel;
   (c) determine the true mean draught at LCF;
   (d) allowance to be made for any hog/sag of the ship;
   (e) density of dock water measured forward, aft and amidships on both sides and mean density determined;
   (f) establish ship's actual displacement and KM from hydrostatic particulars accounting for errors due to trim.
2) 2 or more pendulums should be used to obtain a mean deflection value;
3) Pendulum to be as long as possible and plumb weight suspended in hydraulic oil to dampen movement;
4) Several successive movements of inclining weights to port and starboard done to provide a number of deflection readings to give a more dependable "mean" deflection value;
5) List to be restricted to a small angle to ensure that $\tan\theta = \frac{GG_1}{GM}$ remains valid.

(b)

1) measure the movement of plumb lines across the batten, mark as XY; measure pendulum length, mark as OX;
2) according to similar triangles, $\frac{GG_1}{GM} = \frac{OX}{XY}$, which can be written in $\mathrm{GM} = \frac{OX*GG_1}{XY}$;
3) measure the weight moving across the ship and the light displacement of ship, mark as *w* and *W*; since the movement of *d* distance of weight *w* caused the center of gravity (G) of the ship to shift with a distance of GG_1, $GG_1 = \frac{w*d}{W}$;
4) measure the angle between the pendulum and the center line of the ship, marked as θ; since $\tan\theta = \frac{GG_1}{GM}$, $\mathrm{GM} = \frac{GG_1}{tan\theta} = \frac{w*d}{tan\theta*W}$;
5) $\mathrm{KG} = \mathrm{KM} - \mathrm{GM} = \mathrm{KM} - \frac{w*d}{tan\theta*W}$, where KM is given in hydrostatic particulars.



Q3

(a)(i)

Gross Tonnage is the molded volume of all enclosed spaces of the ship that determines the ship's manning regulations, safety rules, registration fees and port dues etc.

Net Tonnage is the molded volume of cargo spaces of the ship, which refers to the cargo carrying capacity.

(ii)

Plimsoll Line is engraved on both sides of the ship, which indicates the minimum freeboard of the ship in different densities of water. It provides a quick visual check on whether the ship has sufficient reserve of buoyancy.

TF: tropical fresh

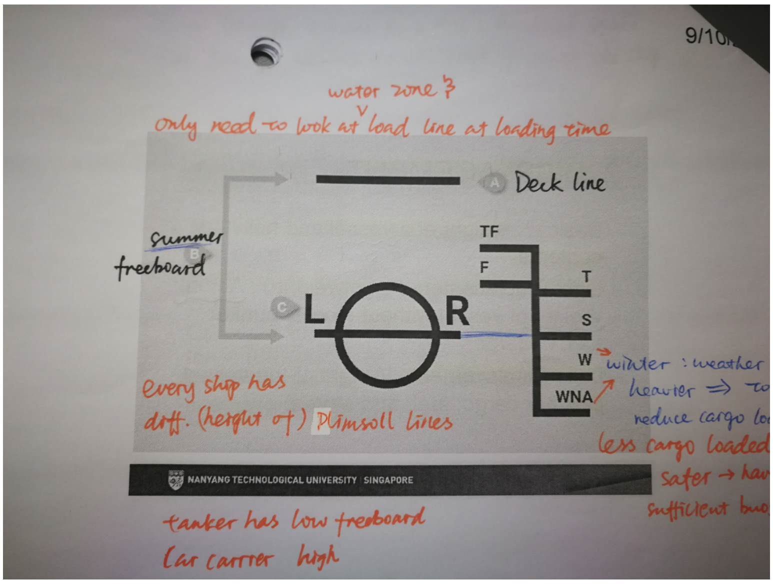
F: fresh water

T: tropical water

S: summer

W: winter

WNA: winter North Atlantic



(b)(i)

Hull fouling is the process that the external surface of ship hull become rough because marine organisms grow and attach on the hull.

(ii)

Hull fouling increases the frictional resistance between ship and seawater and results in loss of speed as well as more fuel consumption. Under normal load, the ship's speed decreases because the work done is partially offset by overcoming the frictional resistance. If the ship wants to keep normal speed, it has to burn more bunker.

Q4

(a)(i)

Two different batch of fuel are compatible if they can be mixed together when injection to the engine. However, compatible fuels cannot be stored together for hours, otherwise they will form sludge. If non-compatible fuel is mixed, the mixture may not be stable and precipitation may take place to form sludge in the tank. This can lead to:

1) Difficulties in pumping the oil
2) Heavy sludge formation in the purifiers
3) Clogging of filters
4) Poor atomization combustion of the fuel

(ii)

Fuel oil stability describes how fast the mixed fuel can form sludge. Blended fuel can become unstable when kept in storage for some time. This result in formation of sludge with same issues as incompatible fuel. Blended lower viscosity fuel tends to become unstable more quickly because they are normally blended lighter fraction.

(b)

Short ignition lag
High specific energy
Fast burning speed
Low cat-fine content

(c)

1. Reject the fuel and de-bunker. However, not always possible because:

- Ship may not have enough fuel to the next port where fuel can be de-bunkered o De-bunker is a slow process and port stay may not be long enough
- Ship may not have adequate system to de-bunker.

2. Compromise and accept the fuel at a discounted price. This is possible only if the fuel can still be used with added treatment or precaution.

- Which property is off-specification?
- What is the extend of off-specification?
- Is it possible to mix the fuel with previous batch in order to use the fuel safely?
- Is it possible to manage and continue to use the fuel safely?
- Will fuel additive help to allow the fuel to be used safely?

(d)

1. The time it takes for the fuel to ignite after ignition (ignition lag)

This can normally be indicated by the Cetane number of the fuel. Ideally, between 40 to 60. Lower Cetane fuel will have longer ignition lag. Fuel with long ignition lag means retarded combustion which leads to lower P_{max} and possible incomplete combustion.

2. How fast does the fuel burn after igniting.

Fuel with good burning speed means higher P_{max} and combustion is more likely to be complete.

Q5

(a)

1. Indicator Diagram

    1) Power = MEP x Length of stroke x Area of piston x engine rpm (PLAN) x Constant
    Power is proportional to MEP x Length of Stoke x Area of piston x engine rpm. This method uses the Mean Effective Pressure (MEP), measured from the power diagram, to estimate the power produced.
    2) Manual Indicators
    Highly unreliable as it relies on operator's skill.
    3) Electronic Indicators
    Drawing of diagrams more reliable but it is still subject to many possible errors due to leakage of gas, twist of the crankshaft, blockage of gas passages.

2. Torque Meter

Power (kW) proportional to Torque (Nm) x Speed (RPM)

Power is proportional to shaft Torque x engine speed. This method measures the twist of the propeller shaft to determine the amount of torque on the shaft and this is used to derive the power produced.

3. Load Indicator x rpm

This method uses the load indicator and engine rpm to estimate the amount of fuel oil injected.

The amount of fuel injected is used to estimate the theoretical power based on the calorific value of the fuel in use.

4. Fuel Consumption

This method uses the load indicator and engine rpm to estimate the amount of fuel oil injected. The amount of fuel injected is used to estimate the theoretical power based on the calorific value of the fuel in use.

5. Turbocharger rpm

The turbocharger rpm is proportional to the amount of exhaust gas produced and the amount of exhaust gas produced is proportional to the amount of fuel burned. As power produced is proportional to the amount of fuel burned, power can be estimated from the rpm of the turbocharger.

(b)

1. Least fluctuating error. There will always be some degree of errors in any of the methods used. It is important that this error is consistent and with least amount of fluctuation.
2. Measure as close as possible to the shaft for less energy loss. Effective power is the power at the propeller shaft. Therefore, to reduce the error from unknown transmission losses, it is preferable that the method used takes measurements as close as possible to the propeller shaft.
3. Minimum estimated correction and assumption. In every method, there are some assumptions and estimated corrections applied. For better reliability, such estimation and assumptions should be minimal. (e.g. fuel pump injecting oil into combustion space, sometimes leakage happens, so each time the amount of injection is different. We assume each time the amount of injection is the same, but we try to make as few assumption as possible)

(c)

1. Maintain efficiency
    - Minimize Consumption
    - Minimize Pollution
2. Maintain reliability
    - Minimize failure and breakdown
    - Improve Safety

(d)

(background, not necessary to answer) When sea water is used as coolant for various machineries in the engine room, these are the issues encountered:

1. Corrosion of pipes
2. Erosion of pipes (sea water is abrasive)
3. Blockage of pipes and cooler tubes by marine growth
4. Difficulties in controlling temperature as cooling flow requirement can fluctuate significantly according to the sea water temperature.

The use central cooling system provide the following advantages:

a) Reduced corrosion in the fresh water system (provided chemical treatment is maintained)

b) Cheaper components of the system (valves, pipes and coolers can be of cheaper material)

c) Easier Cooler Control (constant temperature of cooling water)

d) Reduced maintenance (less filter and cooler cleaning required as there will not be marine growth)