1 (a)

$W = V\rho$

$= LBT\rho$

$200 = 40(6)(T)(1.000)$

$T = 0.8333m$

$KB = \frac{T}{2}$ (Box like vessel)

$= \frac{0.8333}{2}$

$= 0.41665m$.

$BM = \frac{I_{tr}}{\nabla}$

$= \frac{LB^3}{12LB}$ (Box like vessel)

$= \frac{B^2}{12L}$

$= \frac{6^2}{12(0.833)}$

$= 3.600m$.

$KG = 1.20$

$GM = KB + BM - KG$

$= 0.41665 + 3.600 - 1.20$

$= 2.81665$

$\approx 2.82m$.

(b) $GG'_{vertical} = \frac{w \cdot h}{W}$ — refer to diagram in question to see to shifts clearer

$= \frac{50 \cdot [(Depth - 1.20) + 1.25]}{200 + 50}$

$= \frac{50[(2.50 - 1.20) + 1.25]}{250}$

$= 0.51m$.

$GG'_{Horizontal} = \frac{w \cdot h}{W}$

$= \frac{50 \times 1.75}{250}$

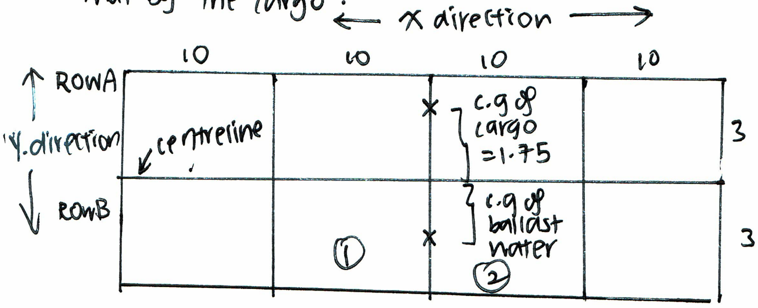
$= 0.35m$.

$\tan\theta = \frac{GG'_{Horizontal}}{GM'}$

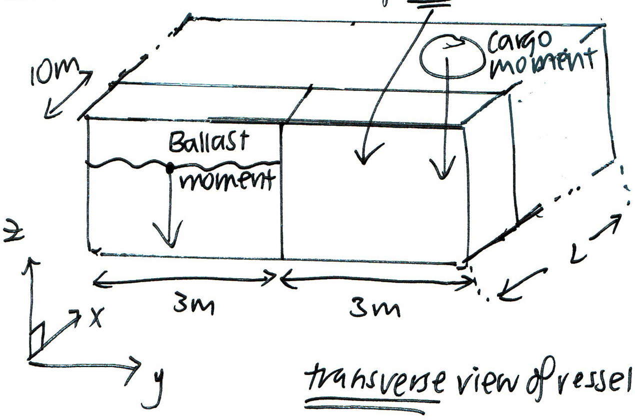
$= \frac{0.35}{2.82 - 0.51}$

$\theta = 8.62°$.

(c) To better understand the solution, we need to know what is happening – there is a heeling ship and we are looking to use ballast water to generate opposing moments about the centre (transverse) against that by the cargo:



Top view of the vessels – each compartment is a ballast tank



transverse view of vessel

* the above is just to illustrate the solutions' thought process; I did not do it during the exam

Actual Ans: moment causing heeling by cargo

$= 50$ tonnes $\times 1.75m$ (weight x distance from centre)

$= 87.5$ ton·m.

Then, we fill 2 out of 4 ballast tanks (→ 1 and 2 ✓✓) of Row B to generate the opposing moment. It doesn't matter which tanks are filled here; they will produce the same moment in the transverse sense. But 1 and 2 will not cause longitudinal instability.

∴ To stabilise, Σ clockwise moment (cargo) = Σ anti clockwise moment (ballast water).

$87.5 = W_{ballast} \times 1.5$

$W_{ballast} = 58.33$ tonnes.

* c.g of ballast $= [\frac{1}{2}(3)] = 1.5$ because tanks are box like.

1(d) We must consider the additional ballast.

$W_{total} = LBT\rho$

$W_{cargo} + W_{ballast} + W_{ship} = 40(6)(T)(1)$

$50 + 58.33 + 200 = 40(6)(T)$

$T = 1.2847$

$KB' = \frac{1.2847}{2} = 0.6424$

$BM' = \frac{B^2}{12T} = \frac{6^2}{12(0.6424)} = 4.6703$

$KG' = 2.82 - 0.51$ (from part b)

$= 2.31$.

$GM_1 = KB_1 + BM_1 - KG_1$

$= 0.64241 + 4.67031 - 2.31$

$= 3.00m$.

(2)

(a)(i) 1. Freshwater tank (Not full) caused free surface effect (fse)

2. Fuel (Not full) caused free surface effect

3. The tilting of ship due to the fse caused sand (fine grained) to have fse.

4. Fuel oil became less viscous in hotter temperature, amplifying FSE.

5. Ice melted → FSE.

(ii) GM due to free surface effect.

FW Tank / fuel tank / sand are free to move or tilt when they are half full due to the presense of free surface.

(iii) 1. Transfer ~~the~~ half of the half tanks to each other and make them full.

2. Freeze the cargo ice.

3. Move the sand cargo if able, to a lower place

(iv) May have resonance and ship will heel too much. at low periods.

- course of sailing may be changed
- speed of vessel may be changed.

2b (i) $W = V\rho = LBT\rho$

$= 3.0(4)(2 \times 3.0)(3)(1.025)$

$= 221.4$

We are assuming the breadth to be according to longest half breadth (3m) → $2 \times 3 = 6m$.

(ii)

Ordinate No.	Halfbeam x	x^3	SM	Product
0	0.2	0.008	1	0.008
1	2.5	15.625	4	62.5
2	3	27	2	54
3	2.1	9.261	4	37.044
4	0.2	0.008	1	0.008

$I_{tr} = \frac{S}{3}(\Sigma product)(\frac{1}{3})(2)$

$= \frac{3}{3}(2 \times 153.56)(\frac{1}{3})$

$= 102.37$

$GM = KB + BM - KG$

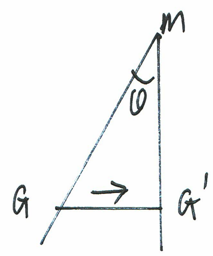
$= \frac{T}{2} + \frac{I_{tr}}{\nabla} - 1.7$

$= \frac{3}{2} + \frac{102.37}{(LBT)} - 1.7$

$= \frac{3}{2} + \frac{102.37}{(12)(6)(3)} - 1.7$

$= 0.274m$.

(iv)



③ (a) 1. Hull form - Optimise the shape to reduce wave/frictional resistance.

2. Bulbous bow - such bulb designs are extensions below waterline are tapered in to reduce resistance on laminar flow.

(b) (i) Weight of the given vessel with everything carried.

(ii) Load displacement - weight of vessel w/ stores/bunker/ cargo
light displacement - weigh of vessel w/o stores/bunker/fuel/cargo

(iii) Deadweight - how much the vessel can safely carry excluding its own weight.
Sum of weights of cargo, freshwater, ballast, provisions, fuel, passenger, crew.

(c)
1. cost
2. Quality
3. Scheduling integrity and reliability - can they deliver on time?
4. Track record - same kind of vessels; what are their results like?
5. relationship w shipyard - better understanding and negotiation
6. Payment terms - payment plans favourable?

* cannot remember how I explained but largely focus on how each factor affects the owner.

4(i) Energy per day = 13560 x 24
= 325 440 kwh *
fuel /day = 325440 x 0.1784 → convert to kg/kwh!
= 58058.496 kg/day.

(ii) Diesel daily consumption = $\frac{42.7}{43.5}$ x 58058.496 = 56990.75 kg/day.

(iii) Time to travel 1000Nm = Distance / speed.
= $\frac{1000}{16}$
= 62.5 hours
= 2.6042 days.

Fuel usage = 2.6042 days x 56990.75 kg/day
= 148413.4115 kg.

(b) - Time for fuel to ignite after ignition : Longer ignition lag retards combustion causing lower P_{max} and hence, chances of incomplete combustion (inefficiency).
- Speed at which fuel burns after ignition : longer to burn means lower P_{max} and higher odds of having incomplete combustion.

c. (i) Amount of sulfur in the fuel - low temperature corrosion. and acid rain
limits: 3.5% in normal places and 0.1% in special Areas.
(0.5% in 2020)

(ii) catalytic fines from refining - causes engine wear (piston ring and liner).
limit: 60mg/kg but ideally <15mg/kg.

(iii) lowest temperature where air/fuel mixes and can be ignited by flame/spark.
limit for fuel : 10°C below it
Engine room: 60°C
lifeboat : >43°C.

(iv) Reduce combustion rate and net heat output
- Absorbs latent heat of vapourisation / affects lubricants and may minimise anti corrosion properties.

5(a) 1. Improve efficiency over wide range of load, fuel injection timing, fuel quantity and exhaust valve timing need to be more precisely controlled. Unattainable by mechanical ones.

2. Satisfy environmental requirement.
The precise control as above describes, allows emissions to be mitigated. Sometimes the combustion may need to be deliberately delayed to reduce emissions.

(b) 1. Gas turbines allows for autonomous shipping (little to no onboard maintanence) compared to 2 stroke engine

2. Starting from cold requires ~2 minutes rather than ~2hrs by 2 stroke engine. allowing scheduling flexibility
← Please confirm w/ Mr Fabian about the explanation. I'm not sure if it is right.

3. Low engine profile allows for more cargo space; 2 strokes are huge

4. Diesel generators allows flexible engine room arrangements compared to 2 strokes

5. Steam engines have highest power output and can be switched w/ gas turbines as compared to one engine of 2 strokes.

(c) (+) Best thermal efficiency → lowest fuel usage and cost
(+) Low SFC → low cost of fuel
(+) able to burn low grade fuel → low cost, less maintanence.
(+) Direct Drive → No gearbox = lesser transmission loss.
(−) High profile of engine − less space for cargo

(d) (+) Less corrosion in FW system − FW not as corrosive as saltwater
(+) Cheaper components − Don't have to be durable against seawater
(+) Easier cooler control. − constant temperature in FW system can be controlled
(+) less maintanence − Not as corrosive for FW.
(−) overheating of one component affects the entire circuit
− FW circuit goes through all compartments.

Most advantage/disadvantages questions need explanations which are taught and requires the correct understanding which was an issue for many; good to check w/ Mr Fabian if there are doubts. He is very helpful/approachable. Some answers here are short because they need elaboration according to your own understanding and I cannot recall my exact answers. Generally, MT2003 requires much background work to understand what you do not know and what to include in cheatsheet. Attending tutorials are important!

Good luck for exams! ‿

− Lee Ying kun
Ying.