Notes on

FIRST MATE CHARTWORK

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GUIDELINES FOR EXAMINATION

- Erase all old lines from the chart before starting work, including all markings along the latitude and longitude scales, and in the compass rose.
- Use 2B pencil and good quality erasure.
- Use transparent plastic protractor and parallel ruler or set squares.
- Measure all bearings and courses by only using the nearest compass rose. Never use the angle markings on the parallel ruler.
- Always use the same edge of the parallel ruler when transferring courses and bearings from/to the compass rose.
- For plotting a point or measuring its latitude and longitude, use the nearest parallel of latitude and meridian, or the compass rose, with the help of parallel ruler. Do not use a compass or divider for this purpose.
- Use appropriate symbols to indicate various parameters like course steered, CTS, CMG, current, celestial azimuth, celestial PL, transferred PL, DR position, estimated position and fix. If you use wrong symbols or no symbols then it would confuse the examiner and you may loose marks.
- State the times of various positions on the chart as stated in the question.
- There are 3 questions in section A (chartwork) and all are compulsory.
- Read the question carefully and write the given data on your answer sheet, except the positions of lights, and double-check the same. If all the necessary data for working the problem is available then start solving it.
- Before starting a problem or after working part of it, if you realize that some data is inadvertently missing or apparently wrong, then inform the invigilator and seek his instructions. Immediately proceed with the next problem and come back to the original problem only after receiving examiner’s instructions.
- If some correction is announced by the invigilator you may respectfully request for extra time which will normally be given.
- Show all calculations required for solving the problem in detail on the answer sheet i.e. the formula, values of each parameter and answer obtained. Merely calculating the values by calculator and writing the answer, will not be accepted by the examiner.
- If some data is calculated by using the Nories tables and not the formula, then mention the name of the table on the answer sheet. Preferably use the formula in all cases.
- After completing the plot on the chart, draw a neat sketch of the plot on the answer sheet, which need not be to scale, and mark the appropriate symbols as stated above.
- Erase all extra or unnecessary lines drawn on the chart, which are not relevant to the plot, to avoid confusing the examiner.

POSITION LINES

1. True visual bearing of an object calculated as follows :
   - Ship's head applied appropriately to relative bearing.
   - Gyro error applied appropriately to gyro compass bearing.
   - Compass error calculated by appropriately combining Deviation from the deviation card, for the given compass course, and Variation as given in the chart / question paper, and applied appropriately to the compass bearing.

2. True Radar bearing of a point of land or Racon, calculated after correcting the relative or gyro compass bearing as stated above.
3. Transit bearing of two objects.
4. Line drawn perpendicular to True Azimuth of a celestial body at ITP, or at DR Lat. and Obs. Long., or at Obs. Lat. and DR Long.

POSITION CIRCLES

1. **Radar distance of point or edge of land, or Racon.**

2. **Raising/dipping or first/last sighting of light**

   Data given --- Light, height of eye and prevailing meteorological visibility.

   - Nominal Range (NR) of light is given in miles on the chart for meteorological visibility of 10 miles.
   - Calculate Luminous Range (LR) of light in miles by entering Luminous Range Diagram with NR of light and given prevailing meteorological visibility which may be less or more than 10 miles.
   - Geographical Range (GR) of light (miles) = $2.095 \times (\sqrt{H} + \sqrt{h})$
     H --- Height of light (m) ; h --- Height of eye (m)
   - If NR / LR > GR, then distance of first/last sighting of light = GR, which is also called raising/dipping distance of light.
   - If NR / LR < GR, then distance of first/last sighting of light = NR / LR.
   - If visibility is given in question then use LR in the above calculation, otherwise use NR.
   - Draw position circle from the light, using the appropriate distance.

3. **Vertical sextant angle of object**

   Data given --- Object, its height as given in chart / question paper, its Vertical sextant angle (VSA), index error (I.E.) of sextant, and rise/fall of tide above/below MHWS.

   - Calculate H (m) = Height of object ± fall/rise of tide
   - Calculate θ' = VSA ± I.E. off/on the arc
   - Calculate distance of object (miles) = $(H \times 1.854) \div \theta' = H \div (\tan \theta' \times 1852.3)$
   - Draw position circle around the object, using the calculated distance.
   - Avoid using Nories tables and ignore height of eye if given.

4. **Horizontal sextant angle**

Data given --- 2 objects, Horizontal sextant angle (HSA) between them, or their compass bearings without compass error.

- HSA (θ°) = Difference between the 2 compass bearings
- Draw a line joining the 2 objects.
- If θ° < 90°, then draw 2 lines towards sea, making an angle of (90° - θ°) at each object.
- If θ° > 90°, then draw 2 lines towards land, making an angle of (θ° - 90°) at each object.
- Intersection of these 2 lines is centre of position circle which will pass through the 2 objects.
- If θ° = 90°, then centre of the line joining the 2 objects is centre of position circle.
- If θ° = 180°, then the ship lies on the line joining the 2 objects.
- *I.E. of sextant is normally not given as its value is much less than 1°.*

5. **Celestial observation**

Draw a position circle with GP (GHA and Decl.) of a celestial body as the centre, and T.Z.D. of the body as radius.

METHODS OF FIXING POSITIONS

1. **Latitude and Longitude**

2. **Intersection of ---**
   - 2 true terrestrial bearings
   - 2 celestial position lines
   - 2 position circles
   - Celestial position line and true terrestrial bearing
   - Position circle and celestial position line
   - Position circle and true terrestrial bearing

3. **Construction of course, speed and current vector triangle**

Data given --- Fix, direction of wind and leeway, and any 4 of the following 6 data : Compass course steered (CS), engine speed, CMG, SMG, and direction and rate of current.

- If compass CS is given then apply deviation and variation appropriately to calculate true CS. Then apply leeway appropriately to calculate corrected true CS.
- Using the 4 given data construct course, speed and current vector triangle XYZ for 1 hour, wherein ---
  - X is initial fix or any position.
  - Z is final position.
  - XZ is CMG and SMG.

- XY is CS / CTS and engine speed, or current direction and rate, depending on construction of the triangle.
- YZ is the remaining parameter.

- Calculate 2 unknown data from the triangle.
- If true CTS is calculated then counteract leeway appropriately to calculate corrected true CTS. Then apply variation and deviation appropriately to calculate compass CTS.
- *Note : Certain combinations of the 4 given data may give 2 possible answers for the 2 unknown data to be calculated. Choose the answers which are most suitable for the given situation on the chart, or seek clarification from the examiner.*

4. Running fix by transferring position line

Data given --- 2 position lines (PL) of 1 or 2 objects/celestial bodies, time interval between 2 observations, direction of wind and leeway, and any 4 of following 6 data : Compass course steered (CS), engine speed, CMG, SMG, and direction and rate of current.

- Draw the 2 PLs.
- Apply deviation and variation appropriately to the given compass CS to calculate true CS. Then apply leeway appropriately to calculate corrected true CS.
- Take any point X on 1st PL and construct course, speed and current vector triangle XYZ for the given time interval, to calculate the remaining 2 data.
- Transfer 1st PL through Z to cut 2nd PL at B which is final position.
- Draw CMG in reverse direction from B to cut 1st PL at A which is initial position.

5. Running fix by transferring position circle

Data given --- 2 position circles (PC) of 1 or 2 objects, time interval between 2 observations, direction of wind and leeway, and any 4 of the following 6 data : Compass course steered (CS), engine speed, CMG, SMG, and direction and rate of current.

- Draw the 2 PCs.
- Apply deviation and variation appropriately to the given compass CS to calculate true CS. Then apply leeway appropriately to calculate corrected true CS.
- Consider the first object as point X and construct course, speed and current vector triangle XYZ for the given time interval, to calculate the remaining 2 data.
- With Z as centre, transfer 1st PC to cut 2nd PC at B which is final position.
- Draw CMG in reverse direction from B to cut 1st PC at A which is initial position.

6. Three bearings of same object

Data given --- 3 true bearings of same object (O), time intervals or distances run between 3 observations, direction of wind and leeway, and any 3 of following 4 data :
Compass course steered (CS), engine speed, and direction and rate of current.

- Draw the 3 given bearings OX, OY and OZ.
- Calculate ratio of 2 time intervals / distances run between OX and OY, and between OY and OZ.
- Draw a line through O, on one side and clear of the 3 bearings.
- Measure convenient distances on this line, on either sides of O, in the above ratio, to obtain points A (on the side of OX) and B (on the side of OZ).
- From A and B draw lines parallel to OY, to cut OX and OZ at C and D respectively.
- Line CD is CMG, but not DMG.
- If compass CS is given then apply deviation and variation appropriately to calculate true CS. Then apply leeway appropriately to calculate corrected true CS.
- Using the 3 given data, calculated CMG, and the point C on OX, construct course, speed and current vector triangle CEF for the given time interval between OX and OZ.
- Measure CF which is DMG.
- Calculate SMG and the 1 remaining data.
- If true CTS is calculated then counteract leeway appropriately to calculate corrected true CTS. Then apply variation and deviation appropriately to calculate compass CTS.
- Transfer OX through F to cut OZ at R.
- Draw CMG in reverse direction from R to cut OX and OY at P and Q respectively.
- P, Q and R are positions at the 3 given bearings.

7. Fix followed by two bearings of same object

Data given --- Fix (X), followed by 2 true bearings of 1 object (O), time intervals or distances run between the fix and 2 bearings, direction of wind and leeway, and any 2 of the following 4 data :
Compass course steered (CS), engine speed, and direction and rate of current.

- Join OX and consider it to be 1^{st} bearing.
- Draw the 2 given bearings OY and OZ and consider them to be 2^{nd} and 3^{rd} bearings.
- Calculate ratio of 2 time intervals / distances run between OX and OY, and between OY and OZ.
- Draw a line through O, on one side and clear of the 3 bearings.
- Measure convenient distances on this line, on either sides of O, in the above ratio, to obtain points A (on the side of OX) and B (on the side of OZ).
- From A and B draw lines parallel to OY, to cut OX and OZ at C and D respectively.
- Line CD is CMG, but not DMG.
- Transfer CMG through X to cut OY and OZ at P and Q respectively, which are positions at the 2 given bearings.
- Measure distance XQ which is DMG. Calculate SMG.

- If compass CS is given then apply deviation and variation appropriately to calculate true CS. Then apply leeway appropriately to calculate corrected true CS.
- Using the 2 given data, calculated CMG and SMG, and the fix X, construct course, speed and current vector triangle for the given time interval between OX and OZ, and calculate the 2 remaining data.
- If true CTS is calculated then counteract leeway appropriately to calculate corrected true CTS. Then apply variation and deviation appropriately to calculate compass CTS.

8. Three bearings of different objects, with current direction but no rate

Data given --- 3 true bearings of 2 or3 objects, time interval between the 3 bearings, compass course steered (CS), engine speed, direction of current, and direction of wind and leeway.

- Draw the 3 bearings OX, OY and OZ from the 2 or 3 objects (*O is commonly used for all the objects*).
- Apply deviation and variation appropriately to the given compass CS to calculate true CS. Then apply leeway appropriately to calculate corrected true CS.
- Take any point A on OX and draw the CS to cut OZ at B.
- Calculate distance run between OX and OY, and measure it from A along the course steered to obtain point C.
- Calculate distance run between OY and OZ, and measure it as BD along the course steered in reverse direction.
- Transfer OX through C (TPL_1).
- Transfer OZ through D (TPL_3), to cut TPL_1 at E.
- Draw direction of current from C to cut TPL_3 at F. (*CF is not drift of current*)
- Draw the course steered from F to cut OZ at G.
- Draw line AG to cut the current CF at H. (*AG is not CMG or DMG*)
- Draw line HE (Ratio line) to cut OY at J.
- Draw direction of current through J to cut TPL_1 and TPL_3 at K and L respectively.
- Draw the course steered in reverse direction from K to cut OX at M.
- Draw the course steered from L to cut OZ at N.
- Line MN is CMG and DMG in the total time interval between OX and OZ.
- Distance KL is drift of current in the total time interval.
- Calculate SMG and rate of current.
- M, J and N are positions at the 3 bearings.

9. Two relative bearings of same object on bow, without current or leeway

Data given --- Fix or compass course steered (CS), 2 relative bearings of 1 object, time interval between the 2 bearings, and engine speed.

- $\alpha° = 1^{st}$ relative bearing.
- $\beta° = 2^{nd}$ relative bearing.
- Calculate D_1 = Distance run between the 2 bearings in given time interval.

- D_2 = Distance of the object at subsequent beam bearing.
- Calculate $D_2 = D_1 \div (\text{Cot } \alpha° - \text{Cot } \beta°)$.
- If fix is given ---
  - Plot position circle for distance D_2 around the object, and draw a tangent to it from fix.
  - This gives CTS and positions when the object will bear α° and β° on the bow, and when it will be abeam.
  - Apply deviation and variation appropriately to calculate true CTS.

- If compass CS is given ---
  - Apply deviation and variation appropriately to calculate true CS.
  - Calculate true bearings of the object when it is α° and β° on the bow, and when it is subsequently abeam.
  - Knowing D_2 measure position at beam bearing.
  - From here plot reverse CS to obtain positions when object is α° and β° on the bow.

Special cases

- If α° = 45° and β° = 90°, then $D_1 = D_2$
- If β° = 2α°, then D_1 = Distance of object at 2^{nd} relative bearing.

10. Resolution of Cocked Hat obtained by 3 terrestrial bearings

Data given --- 3 bearings of 3 objects, having unknown fixed error, which do not meet at a point, and hence form a cocked hat.

Method 1

- Calculate difference between 1^{st} and 2^{nd} bearings, and between 2^{nd} and 3^{rd} bearings.
- Consider the 2 differences to be 2 HSAs.
- Construct 2 position circles as stated in exercise 4 of Position Circles.
- Intersection of the 2 circles is the correct position.

Method 2

- A, B and C are 3 objects.
- Bearings of A and B meet at X, bearings of B and C meet at Y, and bearings of A and C meet at Z, to form cocked hat XYZ.
- Construct perpendicular bisectors of sides of triangle ABX to meet at P.
- With P as centre draw circumcircle of triangle ABX.
- Similarly draw circumcircles of triangles BCY and ACZ.
- Intersection of the 3 circumcircles is the correct position.

11. Rendezvous with a ship at the earliest, without current

Given data --- Positions of both ships, speed of own ship, true course steered and speed of other ship, direction of wind, and leeway as applicable to own ship.

Method 1

- Plot own ship at point A and the other ship at point B on the chart and join them.
- Plot true course steered by the other ship.
- Measure distance traveled by other ship in 1 hour (or 2 hours if scale of chart is small) on its course, to obtain point D.
- From D draw an arc of radius equal to the distance traveled by own ship in the same time interval of 1 or 2 hours, to cut the line AB at point E.
- ED is CMG of own ship. Transfer it to point A to meet course of other ship at point C which is the rendezvous position.
- Counteract leeway appropriately to calculate true CTS of own ship. Then apply variation and deviation appropriately to calculate compass CTS.
- Measure distance AC or BC traveled by the two ships.
- Knowing speeds of both ships calculate time of rendezvous, which should be same for both ships.

Method 2 ---

This method is adopted if plotting work on chart is not possible because the positions of both ships and position of rendezvous are either very far apart or not on the same chart.

- Construct approximate Δ ABC on answer sheet, wherein ---
    - A is position of own ship and B is position of the other ship.
    - C is unknown rendezvous position after unknown T hours.
    - AC is unknown CMG and unknown distance run by own ship at speed S_1 in T hours i.e. $(T \times S_1)$ miles.
    - BC is known CMG and unknown distance run by other ship at speed S_2 in T hours i.e. $(T \times S_2)$ miles.

- Calculate distance AB by Plain Sailing procedure.
- Similarly calculate bearing of A from B and, knowing CMG of other ship, calculate ∠B.
- Calculate ∠A by formula --- $\{ (\text{Sin } A \div (T \times S_2) \} = \{ (\text{Sin } B \div (T \times S_1) \}$.
- Knowing CMG of other ship, ∠A and ∠B, calculate CMG of own ship.
- Knowing ∠A and ∠B, calculate ∠C.
- Calculate time period T, by formula --- $\{ (\text{Sin } B \div (T \times S_1) \} = (\text{Sin } C \div AB)$.
- Knowing speeds S_1 or S_2 and time period T, calculate distance AC or BC.
- Knowing distance AC or BC, and positions of both ships, calculate rendezvous position C by Plain Sailing procedure. It should be same for both ships.
- Knowing CMG of own ship, counteract leeway appropriately to calculate its true CTS. Then apply variation and deviation appropriately to calculate its compass CTS.

12. Rendezvous with a ship at given time

Given data --- Positions of both ships, true course steered and speed of other ship, time of meeting, direction and rate of current, direction of wind, and leeway as applicable to own ship.

Method 1

- Plot own ship at point A and the other ship at point B on the chart.
- Plot true course steered by the other ship.
- Using the given data, construct "one hour" course, speed and current vector triangle at point B to calculate CMG and SMG of other ship.
- Knowing CMG and SMG of other ship, and the given rendezvous time, calculate distance run by other ship and plot rendezvous position C.
- Knowing positions A and C, measure distance AC and CMG of own ship.
- Knowing rendezvous time and distance AC, calculate SMG of own ship.
- Using the given and calculated data, construct "one hour" course, speed and current vector triangle at point A to calculate CTS and engine speed of own ship.
- Knowing CTS of own ship, counteract leeway appropriately to calculate its corrected true CTS. Then apply variation and deviation appropriately to calculate its compass CTS.

Method 2

- Plot own ship at point A and the other ship at point B on the chart.
- Plot true course steered by the other ship.
- Using the given data, construct "one hour" course, speed and current vector triangle at point B to calculate CMG and SMG of other ship.
- Along CMG of other ship measure DMG for 1 hour and plot point D.
- Measure distance AB and divide it by given time interval to obtain distance for 1 hour. Measure this 1 hour distance from point B and plot point E.
- ED is CMG and SMG of own ship.
- Construct "one hour" course, speed and current vector triangle at point A to calculate CTS and engine speed of own ship.
- Knowing CTS of own ship, counteract leeway appropriately to calculate its corrected true CTS. Then apply variation and deviation appropriately to calculate its compass CTS.
- Draw CMGs of both ships to meet at C which is the rendezvous position.

Method 3 ---

This method is adopted if plotting work on chart is not possible because the positions of both ships and position of rendezvous are either very far apart or not on the same chart.

- Using the given data, construct "one hour" course, speed and current vector triangle at any point on the chart to calculate CMG and SMG of other ship.
- Knowing the above data and time of rendezvous, calculate rendezvous position C.
- Knowing positions of own ship and C, and time of rendezvous, calculate CMG and SMG of own ship.

- Construct "one hour" course, speed and current vector triangle at point A, which is position of own ship, to calculate CTS and engine speed of own ship.
- Knowing CTS of own ship, counteract leeway appropriately to calculate its corrected true CTS. Then apply variation and deviation appropriately to calculate its compass CTS.

13. Rendezvous with a stopped ship at the earliest

Given data --- Positions of both ships, engine speed of own ship, other ship is stopped and drifting, direction and rate of current, direction of wind, and leeway as applicable to own ship.

Method 1

- Plot own ship at point A and the other ship at point B on the chart.
- Measure course from own ship to other ship, which is CTS of own ship, and measure distance AB.
- Knowing engine speed of own ship, calculate time interval T to reach point B.
- Knowing CTS of own ship, counteract leeway appropriately to obtain its corrected true CTS. Then apply variation and deviation appropriately to calculate its compass CTS.
- Apply direction and rate of current at point B for time T to obtain rendezvous position C.
- ABC is course, speed and current vector triangle for time T.
- AC is CMG and DMG of own ship.
- Knowing time T calculate SMG of own ship.

Method 2 ---

This method is adopted if plotting work on chart is not possible because the positions of both ships and position of rendezvous are either very far apart or not on the same chart.

- Knowing position of both ships calculate course from own ship at point A to other ship at point B, which is CTS of own ship.
- Calculate distance AB, and knowing engine speed of own ship calculate time interval T to reach point B.
- Knowing CTS of own ship, counteract leeway appropriately to obtain its corrected true CTS. Then apply variation and deviation appropriately to calculate its compass CTS.
- Apply direction and rate of current at point B for time T and calculate rendezvous position C.
- ABC is course, speed and current vector triangle for time T.
- Calculate AC which is CMG and DMG of own ship.
- Knowing time T calculate SMG of own ship.

MISCELLANEOUS CALCULATIONS

1. Sight an object right ahead at certain distance, with current but without leeway

Data given --- Fix (A), engine speed, an object (O) to be sighted right ahead at a distance (D), and direction and rate of current.

- Calculate time period to cover distance D and calculate drift due to current for this time.
- From O draw the given current direction and calculated drift, to obtain point B.
- Draw an arc of radius D around O.
- Draw line AB to cut the arc at C which is position where the object will be sighted right ahead.
- AB is CMG and CB is DMG in the calculated time. Calculate SMG.
- Draw line CO which is true CTS. Apply variation and deviation appropriately to calculate compass CTS.

2. Keep safe distance from an object

Data given --- Initial and final positions (X and Y), engine speed, minimum safe distance to be maintained from an object, direction and rate of current, and direction of wind and leeway

- Plot the 2 positions X and Y.
- Draw circle around the object for the given safe distance.
- From X and Y draw tangents to the circle, to meet each other at A.
- Measure first CMG and DMG from X to A, and second CMG and DMG from A to Y.
- Using the given data and calculated CMGs, construct separate "one hour" course, speed and current vector triangles at X and A to calculate both CTSs and SMGs.
- Calculate time taken on each CMG and hence total time taken between the 2 positions.
- Counteract leeway appropriately to obtain corrected true CTSs. Then apply variation and deviation appropriately to calculate compass CTSs.

3. Keep safe distance from an object while sailing on an arc around it, without current or leeway

Data given --- Initial and final positions (X and Y), engine speed, and minimum safe distance (D) to be maintained from an object (O).

- Plot the 2 positions X and Y.
- Draw position circle around the object O for the distance D.
- From X and Y draw tangents to the position circle, meeting it at A and B respectively.
- Measure first CMG from X to A, and second CMG from B to Y.
- At A the object will be abeam, after which the ship will sail along an arc of the position circle till B, when the ship will be heading on second CMG.
- Measure $\angle AOB$ ($\theta°$) which is difference between the 2 CMGs.

- Calculate distance (miles) along the arc AB = D × θ° ÷ 57.3.
- Calculate total distance and time taken between the 2 positions, assuming that speed along the arc remains constant.

4. Keep safe distance from an object while sailing on an arc of larger radius around it, without current or leeway

Data given --- Initial and final positions (X and Y), engine speed, minimum safe distance (D) to be maintained from an object (O), and radius (R) of arc, greater than D, to sail around the same object.

- Plot the 2 positions X and Y.
- Calculate d = R - D.
- Draw circle of radius D around the object O.
- From X and Y draw tangents to the circle to meet each other at A.
- Join AO and extend it beyond O to B such that OB = d.
- Draw position circle with B as centre and radius R, which will be tangential to first circle.
- From X and Y draw tangents to new position circle to meet it at P and Q respectively.
- Measure first CMG from X to P, and second CMG from Q to Y.
- At P the object will be abeam, after which the ship will sail along an arc of the position circle till Q, when the ship will be heading on second CMG.
- Calculate ∠PBQ (θ°) which is difference between the 2 courses.
- Calculate distance (miles) along the arc PQ = R × θ° ÷ 57.3.
- Calculate total distance and time taken between the 2 positions, assuming that speed along the arc remains constant.

5. Steer safe courses using single position line

Data given --- 1 position line (PL), safe distance to pass an object or a position to reach, engine speed, direction and rate of current, and direction of wind and leeway.

- Draw the PL.
- Draw the given safe distance arc around the object or plot the position to reach.
- Take any point A on the PL and draw first CMG ---
  - Perpendicular to the PL, or
  - Along the PL, or
  - In any convenient direction. (*Not recommended for examination*)

- In the first and third cases, draw a line tangential to the arc or from the position to reach, such that it is parallel to the PL and meets the first CMG at B.
- In the second case, draw a line tangential to the arc or from the position to reach, such that it is perpendicular to the PL and meets the first CMG at B.
- In all cases the tangential point or the position to reach is C.
- AB is first CMG and DMG, but A and B are not positions of the ship.
- BC is second CMG but not DMG.

- Using the given data and calculated CMGs, construct separate “one-hour” course, speed and current vector triangles at A and B to calculate both CTSs and SMGs.
- For each CTS counteract leeway appropriately to calculate corrected true CTSs. (*It is assumed that leeway remains same for both CTSs*).
- Apply variation and deviation appropriately to calculate compass CTSs.
- Knowing first DMG, calculate time interval for alteration of course, but time to reach C cannot be calculated because second DMG is not known.

6. Pass safely between two dangers using VSA

Data given --- 2 objects (A and B), height of A as given in chart / question paper, minimum safe distances from A and B when passing between them, I.E. of sextant, and rise/fall of tide above/below MHWS.

- Apply rise/fall of tide appropriately to height of object A to obtain its corrected height.
- Using given safe distance from A and its calculated height, calculate θ’ as explained in exercise 3 of Position circles.
- Apply I.E. appropriately to θ’ to calculate maximum safe VSA of object A.
- Draw circles of given safe distances around the 2 objects.
- Draw second circle around A, tangential to the circle around B, and measure its radius.
- Using the radius as distance from A, calculate minimum safe VSA as explained above.
- Ship should steer between the 2 objects, by using the minimum and maximum VSAs.

7. Pass safely between two dangers using HSA

Data given --- 2 objects (A and B) on land, 2 shoals (X and Y) located offshore, minimum safe distances from each shoal when passing between them, and I.E. of sextant.

- Draw circles of given safe distances around the shoals X and Y.
- Join objects A and B, and construct PQ as perpendicular bisector of AB.
- By trial and error select a point on PQ such that a circle drawn with it as centre is tangential to the safe distance circle around X, and also passes through A and B.
- Measure α° subtended by AB at any point on this tangential circle.
- Similarly draw second circle tangential to the safe distance circle around Y, and passing through A and B.
- Measure β° subtended by AB at any point on this second tangential circle.
- Apply I.E. appropriately to α° and β° to obtain safe HSAs.
- Ship should steer between the 2 shoals, by using the minimum and maximum HSAs.
- *Note : I.E. may not be given as its value will be insignificant compared to values of HSAs.*

FIRST MATE PHASE I

CHARTWORK QUESTION BANK

Chart No.5046 – Newhaven to Calais
Deviation card No. 2 ; Variation 2° W ; Ship's speed 12 knots

1. Distress ship at 3 miles SE of Greenwich lt. v/l (50° 24.5' N 000° 00') is heading towards Newhaven lt. (50° 46.5' N 000° 03.5' E) at 1 knot. Own ship is at 1 mile NW of Varne lt. v/l (51° 01.5' N 001° 24' E). Calculate compass CTS and earliest time and position of rendezvous with the distress ship.

2. Cap Gris-Nez lt. (50° 52' N 001° 35' E) was first sighted, and after 1 hour it was last sighted. Visibility 2 miles. H.E. 8m. CMG 015° T. Current set 260° T at 3 knots. Leeway was 4° due to Ely wind. Calculate both positions, SMG and compass course steered. From last position calculate compass CTS to sight Sandeme lt. v/l (51° 09' N 001° 47' E) 20° on port bow at 4 miles, assuming no current or leeway.

3. At anchorage Beachy Head lt. (50° 44' N 000° 14.5' E) bore 260° C, Royal Sovereign lt. (50° 43.5' N 000° 26' E) bore 112° C, and Tower (50° 50' N 000° 24' E) bore 022° C. Calculate position and Deviation of compass. From here calculate compass CTS so that after some time Dungeness lt. (50° 56.5' N 000° 59' E) is seen 15° on bow and after further 20 min. it is 30° on bow.

4. Ship in position 50° 47' N 001° 20' E has to reach position 51° 04' N 001° 44' E after going around Cap Gris-Nez lt. at a distance of 8 miles. Calculate compass courses steered and time taken for the voyage.

5. While steering 030° C Cap D'Alprech lt. (50° 42' N 001° 34' E) bore 080° C, and after 30 min. it bore 100° C. After further 45 min. Cap Gris-Nez lt. bore 060° C. Wind SE, leeway 3°, Current 135° T. Calculate CMG, positions at 1st and 3rd bearings, and rate of current.

6. A ship in position 1 mile NW of Varne lt. v/l is steering 260° T at 2 knots. Own ship is West of Pt. Du Banc Haut lt. (50° 24' N 001° 34' E) with its VSA 10'. I.E. 1.5' off the arc. Rise of tide 2m. above MHWS. You have to meet that ship in 3 hours. Current 230° T at 1.5 knots is applicable in the full region. Leeway 2° due to SWly wind is only applicable to own ship. Calculate compass CTS, engine speed and meeting position.

7. From a position 8 miles South of Newhaven lt. a ship runs for 30 min. when Beachy Head lt. bore 010° T. After further 45 min. it bore 320° T. Current 020° T at 2 knots. Wind Sly, leeway 2°. Calculate compass CTS, engine speed and last two positions.

Chart 5047 – Bristol Cannel
Deviation Card No. 3 ; Variation 6° W ; Ship's speed 12 knots

1. At 1600 hr., while steering 031° C, Lundy Island South lt. (51° 10' N 004° 39' W) bore 353° C. At 1620 hr. it bore 285° C and at 1720 hr. Bull Point lt. (51° 12' N 004° 12' W) bore 126° C. Current set 250° T. Calculate the three positions, CMG, SMG, and rate of current.

2. At anchorage, Scarweather lt. v/l (51° 27' N 003° 56' W) bore 340° G, Foreland Point lt. (51° 15' N 003° 47' W) bore 160° G, and Nash Point lt. (51° 24' N 003° 33' W) bore 070° G. Calculate position and Gyro error. From here calculate Gyro CTS, CMG and SMG to sight Helwick lt. v/l (51° 31' N 004° 25' W) right ahead at 9 miles. Current set South at 4 knots. When will the lt. v/l be sighted ahead?

3. At 1900 hr., from position 3 miles North of Horseshoe Rocks buoy (51° 15' N 004° 13.5' W), ship steered an unknown course for 20 min. Subsequently for 30 min. she steered 070° C. Thereafter she steered 347° C till 2005 hr., when Scarweather lt. v/l bore 107° C at 10 miles. Current set NW throughout. Calculate initial compass course and rate of current.

4. At 2100 hr., while steering 022° C, Lundy Island South lt. is first sighted bearing 057° C in visibility of 5 miles. H.E. 18m. From 2130 hr. to 2230 hr. the light was obscured. Calculate the three positions, CMG, SMG, and set and rate of current.

5. While steering 060° C in visibility of 2 miles, St. Gowan lt. v/l (51° 30.5' N 004° 59.5' W) is last sighted. After 45 min. Caldey Island lt. (51° 38' N 004° 41' W) is first sighted. H.E. 10m. Current set 330° T at 3 knots. Calculate both positions, CMG and SMG.

6. At 0400 hr. ship is 8.5 miles North of Lundy Island North lt. (51° 12' N 004° 40.5' W). Calculate compass CTSs and ETA Bristol pilot station (51° 21' N 003° 19' W). Use spring range tidal information given on the chart for high water at Avonmouth at 1000 hr.

7. At 2000 hr., from position with Lundy Island South lt. bearing 045° T at 7 miles, calculate CTS and beam position when the same light will be abeam to port at 2030 hr. From this position calculate Gyro CTS (GE 2° high) and engine speed to reach Bideford pilot station (51° 05' N 004° 15' W) at 2230 hr., allowing for current setting 035° T at 2 knots and leeway of 3° due to Nly wind.

8. Foreland Point lt. bore 157° G (GE 2° high) at 5 miles and Nash Point lt. is 12 miles off. From this position calculate Gyro CTS to first sight Helwick lt. v/l 30° on starboard bow in visibility of 2 miles.

9. At 1500 hr. own ship is at Port Talbot pilot station (51° 28.6' N 004° 00' W) and a distress ship is in position 51° 22' N 004° 45' W. Calculate CMG, compass CTS and ETA to reach her, allowing for current setting South at 2 knots and leeway of 3° due to NWly wind.

10. At 2100 hr., while steering 022° C, Lundy Island North lt. bore 085° C. At 2130 hr. it bore 123° C, 8.4 miles off, and at 2148 hr. it bore 141° C at. Calculate CMG, SMG, and the three positions. From last position calculate compass CTS and engine speed to reach DZ7 buoy (51° 38' N 004° 30'W) at 2400 hr., allowing for the current experienced, and leeway of 4° due to NWly wind.

11. From a position in vicinity of DZ4 buoy (51° 36' N 004° 30' W), calculate compass CTSs and time period to reach anchorage position in chart datum of 14.9m. (51° 35.5' N 004° 51.5' W), maintaining a distance of at least 6 miles from Caldey Island lt., and allowing for current setting North at 2 knots.

12. While steering 035° C Lundy Island South lt. is first sighted in visibility of 5 miles. H.E. 15m. 36 min. later it was obscured. Current set 338° T at 3 knots and leeway was 1° due to Ely wind. Calculate CMG, SMG and both positions.

13. At 0800 hr. VSA of Lundy Island North lighthouse is 20.5' bearing East. I.E. 2' on the arc. Rise of tide 3m. above MHWS. Calculate CMG and compass CTS to sight St. Gowan lt. v/l right ahead 4 miles off. Current set 250° T at 3.5 knots. At 0920 hr. the lt. v/l bore 326° T at 4 miles. Calculate actual set and rate of current.

14. Caldey Island lt. is first sighted, and 30 min. later it is last sighted. Visibility 5 miles. H.E. 10m. Current set North at 4 knots. Leeway 2° due to Sly wind. CMG 270° T and SMG 14 knots. Calculate compass course steered, engine speed and both positions.

15. Lundy Island South lt. bore 030° T and log reading is 100 miles. Subsequently when it bore 000° T log showed 103 miles, and again when it bore 310° T log showed 108 miles. Current set 315° T at 3 knots. Leeway 2° due to SEly wind. Calculate the three positions, CMG and compass course steered.

16. At 2000 hr. Lundy Island South lt. bore 040° T at 8 miles. Calculate Gyro CTS to bring this light abeam to port at 2030 hr. G.E. 2° low. From this position calculate Gyro CTS and engine speed to reach Bideford pilot station at 2230 hr., allowing for current setting 300° T at 2 knots and leeway of 3° due to Sly wind.

17. While steering 090° C at 5 knots in visibility of 1.5 miles, Bull Point lt. is last sighted abeam to starboard. Calculate the position. Thereafter visibility improved to 2 miles, current set 030° T at 1.5 knots and leeway was 2° due to NEly wind. Calculate time period, position and compass bearing of Foreland Point lt. when it will be first sighted.

18. At 2000hr., while steering 185° C, Caldey Island lt. was last sighted. At 2030 hr. course was altered to 143° C. At 2047 hr. Helwick lt. v/l was last sighted. Throughout visibility was 2 miles, current set 210° T at 2.5 knots and leeway was 4° due to SWly wind. Calculate positions at 2000 hr. and 2047 hr.

19. Lundy Island South lt. bore 029° T at 6 miles. From here ship steered a certain course for 1 hour at 9 knots. Then she steered 000° T for 30 min. at 12 knots, when Lundy Island North lt. bore 092° T. Current set 335° T at 3 knots. Calculate final position and initial course.

20. At 1800 hr., while steering 065° C, ship is 6 miles South of Helwick lt. v/l. What will be maximum horizontal angle between the lt. v/l and Porteynon Pt. (51° 32' N 004° 12.5' W) and when will it occur?

21. Ship has to pass between Horseshoe Rocks buoy and Bull Point lt. such that minimum distance from Bull Point lt. is 1.5 miles and minimum distance from buoy is 1 mile. Calculate minimum and maximum VSAs of Bull Point lt. to achieve the above. I.E 2' off the arc. Tide 1.5 m. above MHWS.

22. While steering a certain course, St. Govan's Head (51° 36' N 004° 55.5' W) bore 259° C, Caldey Island lt. bore 079° C and St. Gowan lt. v/l was 30° on bow. After 26 min. the lt. v/l was 60° on bow. Calculate compass course steered without using the deviation tables, and both positions.

23. At 2000 hr., ship steered 273° G from position 51° 05' N 004° 35' W. G.E. 2° low. At 2030 hr. Lundy Island North lt. was sighted for the first time, and at 2100 hr. Lundy Island South lt. was just obscured. Calculate CMG, SMG, both positions, and set and rate of current.

24. At 1900 hr., while steering 040° C, Hartland Point (51° 01.5' N 004° 31.5' W) bore 090° C. At 1945 hr. course was altered to port. At 2015 hr. Lundy Island South lt. bore 252° T and Lundy Island North lt. bore 269° T. Current set 120° T at 1 knot throughout. Calculate the first two positions and compass course steered after alteration.

25. Lundy Island North lt. bore 220° T at 9.9 miles. From here course is steered heading for St. Gowan lt. v/l. However it is first sighted 20° on starboard bow in visibility of 2 miles. Current set 210° T at 1 knot. Calculate CMG, SMG, engine speed and time period for sighting the lt. v/l.

Chart No. 5048 – Old Head of Kinsale to Tuskar Rock
Deviation Card No. 4 ; Variation 7° W ; Ship's speed 10 knots

1. Old Head of Kinsale lt. (51° 36' N 008° 32' W) bore 325° G (G.E. 1° high). Calculate safe gyro CTSs, and the time period for alteration, to reach Cork harbour pilot station (51° 45' N 008° 15' W), counteracting current setting East at 2 knots and leeway of 3° due to Wly wind.

2. At 1900 hr. a ship is at Cork harbour pilot station and steering 130° T at 10 knots, and own ship is 5 miles South of Tuskar Rock lt. (52° 12' N 006° 12.5' W). Current in the area is setting SW at 1.5 knots. Calculate CMGs of both ships, compass CTS and speed of own ship, and rendezvous position with the other ship at 0600 hr. on next day.

3. At 2100 hr., while steering 270° C, Kinsale A-East platform lt. (51° 22' N 007° 57' W) bore 212° C and at 2120 hr. it bore 182° C. At 2140 hr. it bore 137° C, when at the same time Kinsale B-West platform lt. (51° 21.5' N 008° 11' W) bore 172° C. Leeway was 2° due SWly wind. Calculate the three positions, CMG, SMG, and set and rate of current.

4. At 2000 hr., while steering 272° C, Ballycotton Island lt. (51° 49.5' N 007° 59' W) was last sighted in visibility of 5 miles. H.E. 8m. At 2110 hr., in clear visibility, Roche's Point lt. (51° 47' N 008° 15' W) changed from white to red. Current set 049° T at 3 knots and leeway was 4° due to Nly wind. Calculate CMG, SMG and both positions. From last position calculate compass CTS and engine speed to reach Cork harbour pilot station at 2210 hr., allowing for same current but no leeway.

5. At anchorage Stradbally church (52° 08' N 007° 28' W) bore 310° C, Bunmahon church (52° 09' N 007° 22' W) bore 355° C, and Annestown church (52° 08' N 007° 17' W) bore 032° C. Calculate position and Deviation of compass.

6. While steering 240° C, Ballycotton Island lt. was 25° on bow and after 30 min. it was 60° on bow. Calculate position when the light will be abeam. From here calculate compass CTS, CMG, SMG and position to first sight Old Head of Kinsale lt. right ahead in visibility of 5 miles, with current setting SSE at 3 knots. H.E. 12m.

7. At 1900 hr., while steering 062° C, Ballycotton Island lt. bore 310° C. At 1930 hr. it bore 274° C and at 2015 hr. Mine Head lt. (51° 59.5' N 007° 35' W) bore 008° C. Current set 101° T. Calculate CMG, SMG, rate of current and the three positions.

8. At 1900 hr. own ship is in position 51° 30' N 007° 30' W and another ship is stopped in position 51° 45' N 007° 30' W. Current in area is setting SW at 3 knots. Calculate compass CTS and speed of own ship, and position to rendezvous with the other ship at 2100 hr.

Chart No. 5056 – Start Point to The Needles
Deviation Card No. 2 ; Variation 4° W ; Ship's speed 10 knots

1. At 2000 hr., while steering 270° C, Bill of Portland lt. (50° 31' N 002° 27' W) bore 355° C, 5 miles off. At 2030 hr. it bore 050° C, 8.5 miles off. At 2100 hr. engine was stopped for 1.5 hours. From position at 2230 hr. calculate compass CTS and time to reach Exmouth pilot station (50° 36' N 003° 22' W) counteracting the current experienced and leeway of 3° due to Sly wind.

2. At 1900 hr., while steering 275° C in visibility of 2 miles, Bill of Portland lt. is first sighted, and at 2000 hr. it is last sighted. Current set 020° T at 2 knots and leeway was 2° due to Sly wind. Calculate both positions, CMG and SMG. Also calculate compass CTS and engine speed to reach Exmouth pilot station at 2300 hr., allowing for same current and leeway.

3. At 2100 hr., while steering 208° C with leeway of 4° due to Nly wind, Berry Head lt. (50° 24' N 003° 29'W) bore 237° C, at 2130 hr. it bore 256° C and at 2212 hr. it bore 340° C. At 2212 hr. Start Pt. lt. (50° 13' N 003° 30' W) bore 228° C. Calculate CMG, SMG and the three positions. From last position calculate compass CTS to pass 5 miles off Start Pt. lt. allowing for current experienced but no leeway. Also calculate time and bearing of light when it will be abeam.

4. In DR 50° 00' N 002° 00' W, while steering 258° C, a sight gave T. Az. 321° and intercept 2' (T). After 1 hour E. Channel buoy lt. (49° 59' N 002° 29' W) is first sighted in visibility of 5 miles. H.E. 12m. Current set 151° T at 1.5 knots. Leeway was 6° due to Sly wind. Calculate CMG, SMG and both positions.

5. While steering 007° C, following sights are taken using DR 50° 00' N 001° 40' W :
   0600 hr. --- T. Az. 330° --- Intercept 2' (T)
   0630 hr. --- T. Az. 040° --- Intercept 1.4' (A)
   Current set 270° T at 3 knots. Calculate CMG, SMG and both positions. From position at 0700 hr. calculate compass CTS and CMG to sight Needles lt. (50° 39.7' N 001° 35' W) 12 miles right ahead, allowing for same current.

6. At 0810 hr., while steering 045° C, Start Pt. lt. bore 335° C distance 5 miles. After 24 min. course is altered 30° to starboard, and at 0910 hr. original course is resumed. At 0930 hr. Kingswear lt. (50° 21' N 003° 34' W) bore 288° C. Current set 297° T throughout. Calculate final position and rate of current.

7. At anchorage at 2000 hr., Anvil Pt. lt. (50° 35.5' N 001° 57' W) bore 237° C, Handfast Pt. (50° 38.5' N 001° 55' W) bore 264° C, and Occ. WRG lt. (50° 41.5' N 001° 56' W) bore 302° C. Calculate position and Deviation of compass. From here plan a passage to reach Brixham deep-sea pilot station (50° 24' N 003° 22.5' W). Spring high water at Devonport at 2200 hr.

8. From position 50° 00’ N 002° 00’ W calculate compass CTS to first sight Anvil Pt. lt. 45° on port bow in visibility of 5 miles. H.E. 15m. After 2.5 hours the light bore North 6.6 miles off. If leeway was 2° due to Ely wind, calculate set and rate of current, CMG and SMG.

9. Own ship is at Exmouth pilot station. Another ship is in position with E. Channel buoy bearing 128° T at 5.4 miles, and steering 270° T at 8 knots. Calculate compass CTS of own ship and time and position of rendezvous with the other ship.

10. At 1400 hr., while steering 252° C, Bill of Portland lt. bore 302° C, at 1440 hr. it bore 352° C and at 1510 hr. it bore 032° C. Current set 050° T. Calculate the three positions, CMG, SMG, and rate of current.

11. Start Pt. lt. is 6 miles off, and after 1 hour Berry Head lt. is 5 miles off. During this period CMG was 025° T, current set 156° T at 3 knots and leeway was 4° due to NWly wind. Calculate both positions and compass course steered.

12. At 2000 hr., while steering 199° C, Anvil Pt. lt. bore 339° C, at 2020 hr. it bore 359° C, and at 2100 hr. Bill of Portland lt. bore 309° C. Current set 250° T and leeway was 2° due to SEly wind. Calculate the three positions, CMG, SMG and rate of current.

13. From a position with Bill of Portland lt. bearing 344° T, calculate safe compass CTSs to pass Anvil Pt. lt. 5 miles off to port, allowing for current setting 180° T at 2 knots and leeway of 1° due to Wly wind. When will the course be altered?

14. At 2100 hr., while steering 270° C, ship is in position 50° 07’ N 002° 10.6’ W. At 2136 hr. E. Channel buoy bore 221° C, and at 2230 hr. it bore 150° C. Calculate last two positions, CMG, SMG, and set and rate of current.

15. At 0600 hr. ship is in position of 50° 35’ N 001° 40’ W. Calculate compass CTSs and ETA Brixham deep-sea pilot station, passing 6 miles South of Bill of Portland lt. Use spring range tidal information given on the chart for high water at 1200 hr.

16. At 1900 hr., while steering 071° C, Bill of Portland lt. bore 328° C. At 1920 hr. Fixed Red lt. in same position as the first light was first sighted and at 2000 hr. it was last sighted. Current set South. Calculate all the three positions, CMG, SMG, and rate of current.

Chart No. 5072 – Falsterbo to Oland
Deviation Card No. 1 ; Variation 2° E ; Ship's speed 10 knots

1. At 1500 hr., in DR 55° 05' N 016° 00' E, while steering 024° C, a sight gave T. Az. 220° and intercept 2' (T). Current set 270° T at 2 knots. Leeway was 2° due to Ely wind. Engine was stopped at 1600 hr. and resumed course and speed at 1800 hr. Calculate position at 2100 hr. when Utklippan lt. (55° 57' N 015° 43' E) was first sighted in visibility of 5 miles, and also position at 1500 hr. H.E. 10m. From 1800 hr. calculate compass CTS to join Olands Sodra Grund TSS (56° 00' N 016° 38' E).

2. Calculate position when Hammerodde lt. (55° 17' N 014° 46' E) is first sighted bearing 077° T, in visibility of 5 miles. H.E. 15m. From here calculate compass CTS, CMG, SMG and position when Utklippan lt. will be first sighted right ahead. Current set 270° at 2 knots.

3. At anchorage Hano lt. (56° 01' N 014° 51' E) bore 248° C, Tarno lt. (56° 06' N 014° 59' E) bore 306° C, and Gasfeten lt. (56° 07' N 015° 14' E) bore 063° C. Calculate position and Deviation for compass. From here calculate compass CTS and CMG to pass Christianso lt. (55° 19.5' N 015° 11.5' E) 3 miles off to starboard, allowing for current setting 080° T at 3.5 knots and leeway of 5° due to Wly wind. When will the light be abeam?

4. While steering 218° C, Olands Sodra Grund lt. (56° 04' N 016° 41' E) was last sighted, and 1.5 hours later Utklippan lt. was first sighted. Visibility 5 miles. H.E. 9m. Current set 013° T at 2.5 knots. Leeway was 2° due to Nly wind. Calculate CMG and both positions, and time period when Utklippan lt. will be last sighted.

5. At 0530 hr., while steering 255° C, Sandhammaren lt. (55° 23' N 014° 12' E) bore 345° C, at 0600 hr. Kaseberga lt. (55° 23' N 014° 04' E) bore 009° C, and at 0630 hr. Ystad outer breakwater lt. (55° 25' N 013° 49' E) bore 355° C. Current set 240° T. Calculate CMG, SMG, rate of current and the three positions.

6. From position with Christianso lt. bearing 270° T at 5 miles, calculate compass CTS to sight Hano lt. 45° on port bow at 12 miles. 2.5 hours later echo sounder recorded sounding of 10m. (Draft 8m. and rise of tide 1m.). Calculate set and rate of current.

7. From some position East of Hano lt., calculate safe compass CTSs to pass 3 miles South of Utklippan lt. Current set 045° T at 3 knots. Leeway was 5° due NWly wind. When should the course be altered?

8. At 1300 hr. Kullagrund lt. (55° 18' N 013° 20' E) bore 065° T, at 1320 hr. it bore 029° T, and at 1350 hr. it bore 335° T. Current set 152° at 2 knots. Leeway 4° due to NEly wind. Calculate compass CTS, CMG, SMG and the three positions.

9. At 1800 hr., while steering 100° C, Utklippan lt. bore 060° C at 15 miles and at 1900 hr. it bore 010° C at 11.5 miles. Engines were stopped and restarted at 2100 hr. From here calculate compass CTS to reach Olands Sodra Grund TSS. When will the light at the entrance to TSS be first sighted in visibility of 2 miles?

10. At 2000 hr. Svaneke lt. (55° 08’N 015° 10’ E) was last sighted. From here ship steered 346° C. At 2100 hr. engine was stopped. At 2300 hr. Hammerodde lt. was last sighted. Current set 278° T at 2.5 knots and visibility was 5 miles throughout. H.E. 12m. Calculate first and last positions.

11. While steering 256° C, Utklippan lt. bore 043° C at 8 miles. After running for 16 miles by engines, Hano lt. bore 314° C and after further running 8 miles it bore 346° C. Calculate the last 2 positions, CMG, SMG, and set and rate of current.

12. While passing West of Christianso island, CMG is 325° T, Svaneke lt. bore 270° T and current set NE at 4 knots. Subsequently course is to be altered to safely pass 3 miles off Hammerodde lt. Calculate first compass course steered, second compass CTS and time period for alteration.

13. While steering 300° C, Utklippan lt. was seen right ahead at 15 miles. Current set 225° T. After some time the light is estimated to be abeam at 7 miles. Calculate rate of current, CMG, and position and time period when the light is abeam.

14. VSA of Hammerodde lt. is 12.6’, when bearing 137° T. I.E. 2’ on the arc. Tide 2m. below MHWS. Calculate the position. From here course 244° C is steered through current setting 345° T at 2 knots, and leeway of 3° due to Nly wind. Calculate CMG, SMG, and distance and bearing of Sandhammaren lt. when it will be abeam.

15. While steering 062° C, Christianso lt. bore 000° C and Svaneke lt. bore 180° C. Calculate Deviation for compass without using the deviation tables. After 1h 10m a sight taken with DR 55° 15’ N 015° 30’ E, gave intercept 3’ (A) and T. Az. 030°. Current set South at 3 knots. Leeway 4° due to SEly wind. Calculate CMG, SMG and both positions.

Chart No. 5118 – Singapore Strait and Eastern Approaches
Deviation Card No. 1 ; Variation 1° W ; Ship's speed 12 knots

1. While steering 052° C, T. Berakit lt. (01° 13' N 104° 35' E) bore 170° C and Horsburg lt. (01° 20' N 104° 24.5' E) bore 237° C. After 3.5 hours, using DR 02° 00' N 105° 00' E, two simultaneous sights gave T. Az. 290°, intercept 2.5' (A), and T. Az. 240°, intercept 3' (T). Leeway 1° due to Ely wind. Calculate both positions, set and rate of current, CMG and SMG.

2. At anchorage P. Jangkat lt. (00° 58' N 103° 43' E) bore 104° C, Kar. Melvill lt. (00° 52' N 103° 37' E) bore 181° C, and Tanjung Balai lt. (01° 00' N 103° 27' E) bore 284° C. Calculate position and Deviation of compass.

3. At 2000 hr., from position 01° 40' N 104° 20' E, calculate compass CTS to first sight Horsburg lt. right ahead in visibility of 5 miles. Current was estimated to set East at 2 knots. H.E. 15m. At 2045 hr. the light is first sighted 10° on starboard bow in same visibility. Leeway was 5° due to Wly wind. Calculate actual set and rate of current experienced.

4. At 2000 hr., while steering 356° C, Kar. Melvill lt. and P. Jangkat lt. are in transit bearing 040° C. Calculate Deviation of compass. At 2030 hr. P. Jangkat lt. bore 064° C and at 2100 hr. it bore 115° C. Current set SE. Calculate CMG, SMG, rate of current and the three positions. Do not use Deviation card.

5. In DR 01° 00' N 105° 10' E, while steering 330° C, a sight gave T. Az. 025° and intercept 2' (A). When should the ship alter course to safely pass 10 miles North of T. Berakit lt., and what should be the next compass CTS, if current set NE at 3 knots?

6. While steering 240° C, depth contour of 30m. is crossed and Horsburg lt. bore 232° C. Calculate position and compass CTS to sight the light 30° on port bow at 5 miles.

7. At 1400 hr., distress ship is in position 01° 40' N 104° 40' E and rescue ship is in position 01° 20' N 105° 00' E. Current in the area is setting 045° T at 4 knots and the rescue ship is expecting a leeway of 5° due to NEly wind. Calculate rescue ship's compass CTS to reach the distress ship, and meeting time and position.

8. At 1900 hr., while steering 003° C, T. Berakit lt. bore 288° C, at 1930 hr. it bore 268° C, and at 2015 hr. Horsburg lt. bore 268° C. Current set 244° T. Calculate CMG, SMG, rate of current, and the three positions.

Notes on

STABILITY PROBLEM OF DRY DOCKING

Capt. A.K. Prasad

THEORY

1. During dry docking the ship shall be in as light a condition as possible.
2. It shall be trimmed by the stern.
3. Minimum trim required for safe and convenient docking is prescribed by the dock authorities.
4. Chief Officer shall ensure that during the docking process the ship continues to have sufficient positive stability till it is fully sitting on the keel blocks and it is fully supported and secured by the side shores and bilge blocks. Once it is so secured the stability problem ceases to exist.
5. After the ship enters the dry dock and water is being pumped out, first the stern will touch the blocks at the aft perpendicular (AP).
6. Because the stern cannot go down any further, the aft draft will start reducing.
7. This in effect means that the underwater volume of the ship will start reducing.
8. As the ship is still floating, the reduction in underwater volume means that the ship's displacement and the hydrostatic draft would reduce. In other words we can say that some part of the ship's weight is transferred to the land with which it is in contact, or that there is a virtual discharge of weight from the ship.
9. This discharge of weight will occur from the point of contact with the land or keel blocks i.e. the position from where the weight is discharged will be the intersection of AP and the keel.
10. Any discharge of weight from ship causes the ship's COG to shift away from the weight discharged.
11. This means that during dry docking the ship's COG will shift forward and upwards.
12. Upward shift of COG would mean an increase in the KG, or a virtual loss of ship's GM.
13. Forward shift of COG would mean change of trim forward, or reduction of ship's original trim.
14. Hence, as the pumping out of water continues, the ship's displacement, aft draft, hydrostatic draft, GM and trim will keep on reducing. Once the bow of the ship touches the keel blocks, it would be fully resting on the blocks, i.e. it would be on even keel. This condition will not change any further, but the other parameters will continue to reduce.
15. It will be observed that during the above process, the forward draft will steadily increase till the ship reaches even keel, after which it will also reduce along with the aft draft.
16. Once the bow touches the blocks, the dock authorities will place the side shores and bilge blocks in position to fully support the ship. Hence any subsequent loss of GM has no significance because now the ship cannot capsize.
17. It has to be ensured that from the time the ship's stern touches the keel blocks and till the bow touches the blocks, the loss of GM should not result in the ship developing a negative GM because if it happens then the ship will capsize as the shores are not there to support it.

18. Due to this stability aspect, the time interval stated above is called the “Critical period” and the time when the bow touches the blocks is called the “Critical instant”.
19. Hence the Chief Officer should ensure that before entering the dry dock, the ship has sufficiently low KG and minimum FSM so that during the critical period, and at the critical instant, the GM(F) does not become negative.
20. Once the critical instant is reached he should ensure that the dock authorities promptly place the shores in position to fully support the ship. If for any reason it does not happen then the pumping out of the water should be immediately stopped to prevent any further loss of GM.
21. To ascertain the value of the initial GM(F) before entering dry dock, he should calculate the amount of loss of GM during the critical period.

ABBREVIATIONS

D_F & D_A	Drafts forward and aft.
Drop	Fall in water level during dry docking after the stern has touched the blocks.
Hyd	Hydrostatic draft.
P	Loss of weight of ship during dry docking, after stern has touched the blocks.
T	Initial or final trim of the ship as stated.
T_F & T_A	Trim forward and aft.
T_C	Change of trim during dry docking, after the stern has touched the blocks.

FORMULAE APPLICABLE

I T_C (cm.) = P × LCF ÷ MCTC

II Loss of GM (m) = (P × KG) ÷ (W - P)

III GM(F) (m) = KM - KG - Loss of GM - FSC

IV Drop (cm.) = (P ÷ TPC) + {(P × LCF^2) ÷ (MCTC × LBP)}
(This formula is to be used only if the other formulae cannot be used, when the drop in water level is given and the situation is before the C.I.)

CALCULATION OF INITIAL DATA REQUIRED FOR FURTHER CALCULATION

<u>CASE 1</u> --- Data given : D_F and D_A.

Calculate Trim and mean draft. Using mean draft calculate *LCF* from hydrostatic tables.
Calculate Correction = (T × *LCF*) / LBP
(This LCF will not be used again in any calculation.)
Calculate Hyd = D_A - Correction
Using Hyd calculate W, MCTC and LCF from the tables.

CASE 2 --- Data given : W and LCG.

Using W calculate Hyd, MCTC, LCB and LCF from the tables.
Calculate the D_F and D_A as follows :
BG = LCB - LCG ; $T = (W \times BG) / MCTC$
$T_A = (T \times LCF) / LBP$; $T_F = T - T_A$
$D_F = Hyd - T_F$; $D_A = Hyd + T_A$

CASE 3 --- Data given : W and T.

Using W calculate Hyd, MCTC and LCF from the tables.
Calculate the D_F and D_A as follows :
$T_A = (T \times LCF) / LBP$; $T_F = T - T_A$
$D_F = Hyd - T_F$; $D_A = Hyd + T_A$

In addition to the above data, KG and FSM will also be given.

CALCULATION OF FINAL GM(F), DRAFTS AND DROP IN WATER LEVEL AT THE CRITICAL INSTANT (C.I.)

STEP 1 --- CALCULATE THE LOSS OF WEIGHT (P) AT THE C.I.

At C.I. the ship is on even keel, hence Initial $T = T_C$
Formula **I** : $P = (T_C \times MCTC) / LCF$

STEP 2 --- CALCULATE THE FINAL GM(F)

$W_1 = W - P$; Using W_1 calculate KM_1 from the tables.
Formula **II** : Loss of GM $= (P \times KG) / W_1$; $FSC = FSM / W_1$
Formula **III** : $GM(F) = KM_1 - KG - \text{Loss of GM} - FSC$

Note : FSC is applied because it is assumed that at the C.I. the shores are not yet in position. Once these are in position, then the ship will be fully secured and the FSM will cease to exist. Hence the GM will suddenly increase.

STEP 3 --- CALCULATE THE FINAL DRAFTS

Using W_1 calculate Hyd_1 = Final D_F = Final D_A , as the ship is on even keel at the C.I.

STEP 4 --- DROP IN WATER LEVEL is the difference between initial D_A and final D_A.

CALCULATION OF FINAL DRAFTS AND DROP IN WATER LEVEL WHEN THE GM(F) REDUCES TO 'X' m.

STEP 1 --- CALCULATE THE GM(F) AT THE C.I. AS EXPLAINED ABOVE

There will be two possibilities as follows :
Possibility 1 : If GM(F) @ C.I. > X m. then the final GM(F) will reduce to X m. after C.I.
Possibility 2 : If GM(F) @ C.I. < X m. then final GM(F) will reduce to X m. before C.I.

STEP 2 --- CALCULATE LOSS OF WEIGHT (P_1) WHEN FINAL GM(F) = X m.

Using Hyd calculate KM from the tables.
Calculate P_1 by combining Formulae **II & III** as follows :
Possibility 1 : $X = KM - KG - (P_1 \times KG) / (W - P_1)$
Possibility 2 : $X = KM - KG - (P_1 \times KG) / (W - P_1) – (FSM) / (W - P_1)$

Note : FSM will not apply in **Possibility 1** because GM(F) of X m. occurs after the C.I. and hence the shores must be in position.

STEP 3 --- CALCULATE THE FINAL DRAFTS

$W_2 = W - P_1$; Using W_2 calculate Hyd_2 from the tables.
Possibility 1 : Hyd_2 = Final D_F = Final D_A , as the ship will be on even keel after the C.I.
Possibility 2 :

Using Hyd_2 calculate $MCTC_1$ and LCF_1 from the tables.
Formula **I :** $T_C = (P_1 \times LCF_1) / MCTC_1$
Final T = Initial T - T_C
$T_A = (T \times LCF_1) / LBP$; $T_F = T - T_A$
Final $D_F = Hyd_2 - T_F$; Final $D_A = Hyd_2 + T_A$

STEP 4 --- DROP IN WATER LEVEL is the difference between initial D_A and final D_A.

CALCULATION OF FINAL GM(F) AND DRAFTS
AFTER THE WATER LEVEL HAS DROPPED BY 'X' m.

STEP 1 --- CALCULATE THE DROP IN WATER LEVEL AT THE C.I. AS EXPLAINED ABOVE (without calculating GM(F))

There will be two possibilities as follows :
Possibility 1 : If Drop @ C.I. $<$ X m. then the drop of X m. will occur after the C.I.
Possibility 2 : If Drop @ C.I. $>$ X m. then the drop of X m. will occur before the C.I.

STEP 2 --- CALCULATE THE FINAL DRAFTS

Possibility 1 :
Initial D_A - Drop of X m. = Final D_A = Final Hyd_2 = Final D_F , as the ship is on even keel after the C.I.
Using Hyd_2 calculate W_2 and KM_1 from the tables.

Possibility 2 :
Using initial Hyd calculate TPC from the tables.
Calculate P_1 using Formula **IV :** $X = (P_1 / TPC) + (P_1 \times LCF^2) / (MCTC \times LBP)$
$W_2 = W - P_1$; Using W_2 calculate Hyd_2, $MCTC_1$, LCF_1 and KM_1 from the tables.
Formula **I :** $T_C = (P_1 \times LCF_1) / MCTC_1$
Final T = Initial T - T_C
$T_A = (T \times LCF_1) / LBP$; $T_F = T - T_A$
$D_F = Hyd_2 - T_F$; $D_A = Hyd_2 + T_A$

STEP 3 --- CALCULATE THE FINAL GM(F)

Formula **II :** Loss of GM $= (P_1 \times KG) / W_2$; $FSC = FSM / W_2$
Formula **III :**
Possibility 1 : $GM(F) = KM_1 – KG –$ Loss of GM
Possibility 2 : $GM(F) = KM_1 – KG –$ Loss of GM - FSC

Note : FSC will not apply in **Possibility I** because drop of X m. occurs after C.I. and hence the shores must be in position.

CALCULATION OF DRAFTS AND MAXIMUM INITIAL TRIM TO ENTER THE DRY DOCK SO THAT GM(F) AT THE C.I. IS 'X' m.

STEP 1 --- Data given : W, KG and FSM.

Using W calculate Hyd, LCF and KM from the tables.

STEP 2 --- CALCULATE THE LOSS OF WEIGHT (P) AT THE C.I.

Calculate P using Formula **III :** $X = KM - KG - (P \times KG) / (W - P) - (FSM) / (W - P)$

Note : FSM is to be applied assuming that at the C.I. the shores are not yet in position.

STEP 3 --- CALCULATE THE INITIAL DRAFTS

$W_1 = W - P$; Using W_1 calculate Hyd_1, $MCTC_1$ and LCF_1 from the tables.
Formula **I :** Initial $T = (P \times LCF_1) / MCTC_1$
$T_A = (\text{Initial } T \times LCF_1) / LBP$; $T_F = \text{Initial } T - T_A$
$D_F = Hyd_1 - T_F$; $D_A = Hyd_1 + T_A$

DIFFERENCE BETWEEN DRY DOCKING AND GROUNDING

<table>
<tr><th>ITEM</th><th>DRY DOCKING</th><th colspan="2">GROUNDING</th></tr>
<tr><td>Initial displacement</td><td>Light, without cargo and with minimum ballast.</td><td colspan="2">Any value.</td></tr>
<tr><td>Initial trim</td><td>By stern, minimum as decided by dry dock authorities, maximum as decided by ship.</td><td colspan="2">Any value by head or stern</td></tr>
<tr><td>List</td><td>Nil</td><td colspan="2">Nil</td></tr>
<tr><td>Initial GM(F)</td><td>Adequate, to ensure +ve GM(F) at C.I.</td><td colspan="2">Any value.</td></tr>
<tr><td>Change of displacement</td><td>Due to drop in water level when dry dock is pumped out.</td><td colspan="2">Due to fall of tide.</td></tr>
<tr><td>Change of trim</td><td>By head.</td><td colspan="2">Opposite to point of contact.</td></tr>
<tr><td>Critical instant (C.I.)</td><td>Occurs when bow touches keel blocks.</td><td colspan="2">N.A.</td></tr>
<tr><td>Side shores or Bilge blocks</td><td>Fixed at C.I.</td><td colspan="2">N.A.</td></tr>
<tr><td>Capsizing</td><td>Cannot happen because Side shores or Bilge blocks are placed at C.I.</td><td colspan="2">Can happen because there are no Side shores or Bilge blocks.</td></tr>
<tr><td></td><td></td><td>BEACH</td><td>ROCK</td></tr>
<tr><td>Point of contact</td><td>Aft perpendicular</td><td>Forward or aft perpendicular</td><td>Any where</td></tr>
<tr><td>Final trim</td><td>Even keel</td><td>As per slope of beach</td><td>Any value</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Notes on

STABILITY PROBLEM OF GROUNDING

Capt. A.K. Prasad

THEORY

1. Grounding is similar to dry-docking, but with certain modifications as follows :
   a. Ship may have any displacement.
   b. Trim may be by the stern or by the head or the ship may be on even keel.
   c. The point of contact on grounding may be anywhere from forward to aft.
   d. Ship may run aground on a sloping beach in which case the point of contact will be either the FP or the AP. As the tide falls, the trim will change, depending on the point of contact, and the ship may finally come to rest on the beach. The final trim may be by the head or by the stern, according to the slope of the beach, regardless of the original trim.
   e. Ship may run aground on a rock at any point along its length, with deep waters at both ends. As the tide falls, the trim will change continuously, depending on the point of contact. There is no rest position.

2. After grounding and with the fall of tide, the underwater volume, hydrostatic draft, displacement and GM(F) will reduce, as in the case of dry docking, but the trim may increase or decrease or change in direction, depending on the point of contact and the initial trim.
3. Unlike dry-docking there are no side shores or bilge blocks and so the ship is never secured. Hence, even if the ship comes to rest on a beach and the tide continues to fall, the FSM will always apply. It also means that at some stage of fall of tide, the GM(F) may become negative and the ship is likely to capsize.
4. Because all the parameters continuously change with the fall of tide, there is no such thing as critical period or critical instant.
5. The drop in water level due to fall of tide will be measured at the point of contact, which may be anywhere along the length of the ship.

ABBREVIATIONS

D_F , D_A & D_R	Drafts forward, aft and at the rock or point of contact.
d	Distance of the rock or the point of contact from the COF
Fall in tide	Fall in tide after the first contact.
Hyd	Hydrostatic draft.
P	Loss of weight of the ship due to fall in tide after the first contact.
T	Initial or final trim of the ship as stated.
T_F , T_A & T_R	Trim forward, aft and at the rock or point of contact.
T_C	Change of trim due to fall in tide after the first contact.

FORMULAE APPLICABLE

I T_C (cm.) = (P × d) ÷ MCTC

II Loss of GM (m) = (P × KG) ÷ (W - P)

III GM(F) (m) = KM - KG - Loss of GM - FSC

IV Drop (cm.) = (P ÷ TPC) + {(P × d^2) ÷ (MCTC × LBP)}
(This formula is to be used only if the other formulae cannot be used, when the drop in water level is given and the situation is before the C.I.)

CALCULATION OF INITIAL DATA REQUIRED FOR FURTHER CALCULATION

CASE 1 --- Data given : D_F and D_A .

Calculate Trim and mean draft. Using mean draft calculate *LCF* from hydrostatic tables.
Calculate Correction = (T × *LCF*) / LBP
(This LCF will not be used again in any calculation.)
Calculate Hyd = D_A ± Correction *(Sign will depend on the trim.)*
Using Hyd calculate W, MCTC and LCF from the tables.

CASE 2 --- Data given : W and LCG.

Using W calculate Hyd, MCTC, LCB and LCF from the tables.
Calculate the D_F and D_A as follows :
BG = LCB ~ LCG ; T = (W × BG) / MCTC
T_A = (T × LCF) / LBP ; T_F = T - T_A
D_F = Hyd ± T_F ; D_A = Hyd ± T_A *(Sign will depend on the trim.)*

CASE 3 --- Data given : W and T.

Using W calculate Hyd, MCTC and LCF from the tables.
Calculate the D_F and D_A as follows :
T_A = (T × LCF) / LBP ; T_F = T - T_A
D_F = Hyd ± T_F ; D_A = Hyd ± T_A *(Sign will depend on the trim.)*

In addition to the above data, following data will also be given :
- KG and FSM
- The point of grounding, i.e. F.P. or A.P., and the slope of the beach, OR
- The point of contact in case of grounding on a rock.

CALCULATION OF FINAL GM(F), DRAFTS AND FALL OF TIDE AFTER THE SHIP RUNS AGROUND AT F.P. OR A.P. AND COMES TO REST POSITION ON THE BEACH

STEP 1 --- CALCULATE THE LOSS OF WEIGHT (P)

Final trim of the ship will be the slope of the beach as given in the data.
T_C = Initial T ± Final T
Calculate distance d as follows :

If point of grounding is at the A.P. : d = LCF
If point of grounding is at the F.P. : d = LBP – LCF

Formula **I :** $P = (T_C \times MCTC) / d$

STEP 2 --- CALCULATE THE FINAL GM(F)

$W_1 = W - P$; Using W_1 calculate KM_1 from the tables.
Formula **II :** Loss of GM = $(P \times KG) / W_1$; FSC = FSM / W_1
Formula **III :** GM(F) = KM_1 – KG - Loss of GM - FSC

STEP 3 --- CALCULATE THE FINAL DRAFTS

Using W_1 calculate Hyd_1 and LCF_1 from the tables.
$T_A = (\text{Final T} \times LCF_1) / LBP$; $T_F = \text{Final T} - T_A$
$D_F = Hyd_1 \pm T_F$; $D_A = Hyd_1 \pm T_A$ *(Sign will depend on the final trim.)*

STEP 4 --- FALL OF TIDE is change in draft at the point of grounding, i.e. F.P. or A.P.

CALCULATION OF FINAL DRAFTS AND FALL OF TIDE AFTER THE SHIP RUNS AGROUND ON THE BEACH AND THE GM(F) REDUCES TO 'X' m.

STEP 1 --- CALCULATE THE GM(F) AT THE REST POSITION ON THE BEACH, AS EXPLAINED IN PROBLEM 1

There will be two possibilities as follows :
Possibility 1 :
If GM(F) @ Rest > X m. then final GM(F) will reduce to X m. after the rest position.
Possibility 2 :
If GM(F) @ Rest < X m. then final GM(F) will reduce to X m. before the rest position.

STEP 2 --- CALCULATE LOSS OF WEIGHT (P_1) WHEN FINAL GM(F) = X m.

Using Hyd calculate KM from the tables.
Calculate P_1 by combining Formulae **II & III :**

$$X = KM - KG - (P_1 \times KG) / (W - P_1) - FSM / (W - P_1)$$

STEP 3 --- CALCULATE THE FINAL DRAFTS

$W_2 = W - P_1$; Using W_2 calculate Hyd_2 , $MCTC_1$ and LCF_1 from the tables.

Possibility 1 : Tide has fallen beyond the rest position, hence the final trim is the slope of the beach.
Calculate the final D_F and D_A as explained in Step 3 of Problem **1.**

Possibility 2 ---
Calculate distance d_1 as follows :
If point of grounding is at the A.P. : $d_1 = LCF_1$
If point of grounding is at the F.P. : $d_1 = LBP - LCF_1$
Formula **I :** $T_C = (P_1 \times d_1) / MCTC_1$
Final T = Initial T $\pm T_C$

If initial trim is by the stern and the point of contact is at AP --- Subtract
If initial trim is by the stern and the point of contact is at FP --- Add
If initial trim is by the head and the point of contact is at FP --- Subtract
If initial trim is by the head and the point of contact is at AP --- Add

Calculate the final D_F and D_A as explained in Step 3 of Problem **1.**

STEP 4 --- FALL OF TIDE is change in draft at the point of contact i.e. at FP or AP.

CALCULATION OF FINAL GM(F) AND DRAFTS AFTER THE SHIP RUNS AGROUND ON THE BEACH AND THE TIDE FALLS BY 'X' m.

STEP 1 --- CALCULATE THE FALL OF TIDE UPTO THE REST POSITION ON THE BEACH, AS EXPLAINED IN PROBLEM 1

There will be two possibilities as follows ---
Possibility 1 :
If fall of tide upto Rest < X m. then fall of tide of X m. will occur after the rest position.
Possibility 2 :
If fall of tide upto Rest > X m. then fall of tide of X m. will occur before the rest position.

STEP 2 --- CALCULATE LOSS OF WEIGHT (P_1) WHEN FALL OF TIDE = X m.

Using Hyd calculate TPC from the tables.
Calculate distance d as explained in Step 1 of Problem **1.**
Calculate P_1 using Formula **IV :** $X = (P_1 / TPC) + (P_1 \times d^2) / (LBP \times MCTC)$

STEP 3 --- CALCULATE THE FINAL DRAFTS

Possibility 1 : Tide has fallen beyond the rest position, hence the final trim is the slope of the beach.
Initial D_A / D_F - Fall of X m. = Final D_A / D_F ; Final D_A / D_F ± Final T = Final D_F / D_A
Note : *Sign will depend on the final trim. Value of P is not required.*
Initial D_A or D_F will be used depending on whether the ship has run aground at A.P. or F.P. respectively.

Possibility 2 :
$W_2 = W - P_1$; Using W_2 calculate Hyd_2 , $MCTC_1$ and LCF_1 from the tables.
Calculate distance d_1 as explained in Step 3 of Problem **2.**
Formula **I :** $T_C = (P_1 \times d_1) / MCTC_1$
Final T = Initial T ± T_C
Note : *Sign will be as explained in Problem* ***2****.*

Calculate the final D_F and D_A as explained in Step 3 of Problem **1.**

STEP 4 --- CALCULATE THE FINAL GM(F)

Using Hyd_2 calculate KM_2 from the tables.
Formula **II :** Loss of GM = $(P_1 \times KG) / W_2$; FSC = FSM / W_2
Formula **III :** GM(F) = KM_2 – KG – Loss of GM - FSC

CALCULATION OF FINAL DRAFTS AND FALL OF TIDE AFTER THE SHIP RUNS AGROUND ON A ROCK AND THE GM(F) REDUCES TO 'X' m.

(There is deep water at forward and aft ends)

<u>STEP 1</u> --- CALCULATE LOSS OF WEIGHT (P) WHEN FINAL GM(F) = X m.

Using Hyd calculate KM from the tables.
Calculate P by combining Formulae **II & III :**

$$X = KM - KG - (P \times KG) / (W - P) - FSM / (W - P)$$

<u>STEP 2</u> --- CALCULATE THE FINAL DRAFTS

$W_1 = W - P$; Using W_1 calculate Hyd_1, $MCTC_1$ and LCF_1 from the tables.
Calculate distance d_1 of the rock from COF_1 using LCF_1 and data about point of contact.
Formula **1 :** $T_C = (P \times d_1) / MCTC_1$
Final T = Initial T $\pm T_C$
Note : *Sign will be as explained in Problem* ***2****.*

Calculate the final D_F and D_A as explained in Step 3 of Problem **1.**

<u>STEP 3</u> --- CALCULATE THE FALL OF TIDE

Calculate initial distance d of the rock from the COF using the given data.
Initial trim at the rock (T_R)= (Initial T $\times$ d) / LBP
Initial draft at the rock (D_R)= Hyd $\pm$ Initial T_R

If initial trim is by the stern and the rock is forward of COF --- Subtract
If initial trim is by the stern and the rock is aft of COF --- Add
If initial trim is by the head and the rock is aft of COF --- Subtract
If initial trim is by the head and the rock is forward of COF --- Add

Final T_R = (Final T $\times d_1$) / LBP ; Final $D_R = Hyd_1 \pm$ Final T_R
(Apply sign as explained above)

Fall of tide = Initial D_R - Final D_R

CALCULATION OF FINAL GM(F) AND DRAFTS AFTER THE SHIP RUNS AGROUND ON A ROCK AND THE TIDE FALLS BY ‘X’ m.

(There is deep water at forward and aft ends)

STEP 1 --- CALCULATE THE LOSS OF WEIGHT (P)

Using Hyd. calculate TPC from the tables.
Calculate distance d of the rock from the COF using the given data.
Calculate P using Formula **IV :** $X = (P / TPC) + (P \times d^2) / (LBP \times MCTC)$

STEP 2 --- CALCULATE THE GM(F)

$W_1 = W - P$
Formula **II :** Loss of GM = $(P \times KG) / W_1$; $FSC = FSM / W_1$
Using W_1 calculate KM_1 from the tables.
Formula **III :** $GM(F) = KM_1 – KG –$ Loss of GM - FSC

STEP 3 --- CALCULATE THE FINAL DRAFTS

Using W_1 calculate Hyd_1, $MCTC_1$ and LCF_1 from the tables.
Calculate distance d_1 of the rock from COF_1 using LCF_1 and data about point of contact.
Formula **1 :** $T_C = (P \times d_1) / MCTC_1$
Final T = Initial T $\pm T_C$
Note : *Sign will be as explained in Problem* ***2****.*

Calculate the final D_F and D_A as explained in Step 3 of Problem **1.**