ANNEX B OF CMO NO. 20, SERIES OF 2015
BACHELOR OF SCIENCE IN MARINE TRANSPORTATION
COURSE SPECIFICATIONS

Course Code	**:**	Seam 2B
Course Descriptive Title	**:**	Trim, Stability and Stress 2
Course Credits	**:**	6 units
Lecture Contact Hours per Week	**:**	6 hours
Laboratory Contact Hours per Week	**:**	0 hours
Prerequisite	**:**	Seam 2A
Reference/s	**:**	1. Table A-II/2 of the 1978 STCW Code as amended Function: Controlling the operation of the ship and care for persons on board at the management level 2. Annex A of CMO No. 20, Series of 2015 (Curriculum Mapping for BSMT)

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
Control trim, stability and stress	Understanding of fundamental principles of ship construction and the theories and factors affecting trim and stability and measures necessary to preserve trim and stability	Stability *Approximate Calculation of Areas and Volumes* – States the trapezoidal rule for the area under a curve in terms of the number of ordinates, the interval and the ordinate values – Uses the trapezoidal rule to find the area under a curve defined by given ordinates – States Simpson's first rule as A= h (y1 + 4y2 + y3) / 3 where: A = area under curve	83

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		h = interval length y1, y2, y3 are ordinates – Writes down the repeated first rule for any odd number of ordinates – Uses Simpson's first rule to find the area under a curve defined by an odd number of ordinates – States that the area is exact for a linear, quadratic or cubic curve but an approximation otherwise – States, Simpson's second rule as A = 3h (y1 + 3y2 + 3y3+ y4) / 8 where: A = area h = interval length y1, y2, y3, y4 are ordinates – Writes down the repeated second rule for 7, 10, 13, etc, ordinates – Uses Simpson's second rule to find the area under a curve defined by a suitable number of given ordinates – States that the area is exact for linear, quadratic or cubic curves – States that the first rule has smaller errors that the second and should be used in preference where possible – States that errors can be reduced by using a smaller interval – States the 5, 8, -1 rule as A = h(5y1 + 8y2 - y3) / 12 where: A = area between first and second ordinates h = interval length y1, y2, y3, are ordinates – Uses Simpson's rules to find the area under a curve defined by any number of ordinates – Explains that the volume of a body may be calculated by using Simpson's rules with cross-sectional areas as ordinates	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		– Calculates the volume of a ship to a stated draught by applying Simpson's rules to given cross-sectional areas or waterplane areas – Uses Simpson's first, second and 5/8-1 Rules to approximate areas and volumes of ship structure and GZ curves with any number of ordinates and intermediate ordinates <u>Effects of Density</u> – Given the density of the water in the dock, calculates the displacement for a particular draught from the seawater displacement for that draught extracted from hydrostatic data – Calculates the TPC for given mean draught and density of the dock water – Discusses the use of the Fresh Water Allowance and how to determine this for a ship – States that FWA only applies when the ship is floating at or near its summer load line – Explains why the density of the water in the dock should be taken at the same time as the draughts are read – States that the virtual rise of G or apparent reduction in effective GM due to free surface affect (in metres) at small can be calculated – Describes the statical and dynamic effects on stability of the movement of liquids with a free surface – Calculates the virtual reduction in GM for liquids with a free surface in spaces with rectangular and triangular waterplanes – Deduces from the above objective that halving the breadth of a tank reduces the free surface effect to one eight of its original value – Deduces that the subdividing a tank at the centre reduces its free surface effect to one quarter of that of the undivided tank	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		– States that the quantity 'inertia x density of liquid' is called the 'free surface moment' of the tank, in tonne-metres – States that information for calculating free surface effect is included in tank capacity tables – States that the information may be given in one of the following ways: – inertia in $metre^4$ – free surface moments for a stated density of liquid in the tank – as a loss of GM, in tabulated form for a range of draughts (displacements) for a stated density of liquid in the tank – Corrects free surface moments when a tank contains a liquid of different density from that slated in the capacity table – Given a ship's displacement and the contents of its tanks, uses the information from ship's stability information a capacity table to calculate the loss of GM due to slack tanks – Given a ship's departure conditions and the daily consumption of fuel, water and stores, calculates the GM allowing for free surfaces on arrival at destination – Stability at Moderate and Large Angles of Heel – States that the formula GZ = GM sin θ does not hold for angles in excess of about 10º – States that the initial KM is calculated from KM = KB + BM – Uses a metacentric diagram to obtain values of KM, KB and BM for given draughts – States that the transverse BM = I / V Where: I = second moment of area of the waterplane about the centre line; V = underwater volume of the ship – States that for a rectangular waterplane $I = LB^3/ 12$ Where: L is the length of the waterplane;	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		B is the breadth of the waterplane – Shows that, for a box-shaped vessel, $KM = (B^2 / 12d) + (d / 2)$ Where: d = draught – States that, for moderate and large angles of heel, values of GZ found by calculating the position of the centre of buoyancy are provided by the shipbuilder for a range of displacements and angles of heel for an assumed position of the centre of gravity – Uses cross-curves of stability and KN curves to construct a curve of statical stability for a given displacement and value of KG, making correction for any free surface moments – Explains how to use the initial metacentric height as an aid to drawing the curve – Identifies from the curve the approximate angle at which the deck edge immerses – Describes the effect of increased freeboard on the curve of statical stability for a ship with the same initial GM – States that the righting lever, GZ, may be found from the wall-sided formula up to the angle at which the deck edge is immersed – Given the wall-sided formula: $GZ = (GM + BM / 2 \tan^2\varphi) \sin\varphi$ and other relevant data, calculates the value of GZ for a stated angle of heel – Shows that, for small angles of heel, the term – $BM / 2 \tan^2\varphi$ is negligible, leading to the usual expression for GZ at small angles of heel – Uses the wall-sided formula for calculating the angle of loll of an initially unstable ship – Compares the result in the above objective with that obtained by connecting a curve of statical stability	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS

		– States that cross-curves and KN curves are drawn for the ship with its centre of gravity on the centre line
		– Demonstrates how to adjust the curve of statical stability for a ship with a list
		– Describes the effect when heeled to the listed side on:
		  – the maximum righting moment
		  – the angle of vanishing stability
		  – the range of stability
		– States that cross-curves and KN curves are drawn for the ship at the designed trim when upright
		– States that righting levers may differ from those shown if the ship has a large trim when upright
		
		<u>Simplified Stability Data</u>
		
		– States that stability information may be supplied in a simplified form, consisting of:
		  – a diagram or table of maximum deadweight moment
		  – a diagram or table of minimum permissible GM
		  – a diagram or table of maximum permissible KG all related to the displacement or draught in salt water
		– States that a deadweight moment is mass in tonnes X vertical height of the mass above the keel
		– States that free surface moments are to be added to the deadweight moments when using the diagram of maximum deadweight moment
		– States that if, for a stated displacement or draught, the total deadweight moment or KG is less than the maximum permissible value, the ship will have adequate stability	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		– Reads the maximum permissible deadweight moment from a curve of deadweight moment for a given displacement – Given the masses loaded, their heights above the keel and the free surface moments of slack tanks, calculates the deadweight moment and uses the result with the diagram of deadweight moment to determine if the stability is adequate – Uses the diagram of deadweight moment to calculate the maximum mass that can be loaded in a given position to ensure adequate stability during a voyage, making allowance for the fuel, water and stores consumed and for any resulting free surface – States that curves of maximum KG or minimum GM to ensure adequate stability in the event of partial loss of intact buoyancy are provided in passenger ships <u>Trim and List</u> – Defines longitudinal centre of gravity (LCG) and longitudinal centre of buoyancy (LCB) – States that a ship trims about the centre of flotation until LCG and LCB are in the same vertical line – States that a ship trims about the centre of flotation until LCG and LCB are in the same vertical line – States that the distance of the LOB from amidships or from the after perpendicular is given in a ship‘s hydrostatic data for the ship on an even keel – Explains that the LCG must be at the same distance from amidships as LCB when the ship floats on an even keel – Shows on a diagram of a ship constrained to an even keel the couple that is formed by the weight and buoyancy forces when LCG is not the same distance from amidships as LCB	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		– States that the trimming moment = displacement x the horizontal distance between LCB (tabulated) and LCG (actual) = Δ x GG_1 where GG1 is the horizontal distance between the position of LCG for the even- keel condition and the actual LCG – States that trim = (Δ x GG_1) / MCT 1cm – States that if the actual LCG is abaft the tabulated position of LCB, then the trim will be by the stern, and vice versa – Given the initial displacement, initial position of LCG, masses loaded or discharged and their LCGs, calculates the final position of LCG – Using a ship's hydrostatic data and a given disposition of cargo, fuel, water and stores, determines the trim, the mean draught and the draughts at each end – Calculates the mass to move between given positions to produce a required trim or draught at one end – Calculates where to load a given mass to produce a required trim or draught at one end – Calculates how to divide a loaded or discharged mass between two positions to produce a required trim or draught at one end – Calculates where to load a mass so as to keep the after draught constant – States that calculated draughts refer to draughts at the perpendiculars – Given the distance of draught marks from the perpendiculars and the length between perpendiculars, corrects the draughts indicated by the marks – Given draughts forward, aft and amidships, states whether or not the ship is hogged or sagged and the amount – Corrects the draught amidships for hog or sag	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		– Given the forward and after draughts, the length between perpendiculars and hydrostatic data, calculates the correction for trim to apply to the displacement corresponding to the draught amidships – States that a second correction for trim, using Nemoto‘s formula, may be applied to the displacement – Given Nemoto‘s formula, calculates the second correction to displacement – Calculates the maximum list during loading or discharging a heavy lift, using a ship‘s derrick, given the relevant stability information and the dimensions of the derrick – Calculates the minimum GM required to restrict the list to a stated maximum when loading or discharging a heavy lift – Calculates the quantities of fuel oil or ballast to move between given locations to simultaneously correct a list and achieve a desired trim – Explains how to distinguish between list and loll and describes how to return the ship to the upright in each case – By making use of curves of statical stability, including those for ships with zero or negative initial GM, determines the equilibrium angle of heel resulting from a transverse moment of mass <u>Dynamical Stability</u> – Defines dynamical stability at any angle of heel as the work done in inclining the ship to that angle – States that the dynamical stability at any angle is given by the product of displacement and the area under the curve of statical stability up to that angle	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		– Given a curve of statical stability, uses Simpson's rules to find the area in metre-radians up to a stated angle – States that dynamical stability is usually expressed in tonne-metres – Explains that the dynamical stability at a given angle of heel represents the potential energy of the ship – States that the potential energy is used partly in overcoming resistance to rolling and partly in producing rotational energy as the ship returns to the upright – States that the rotational energy when the ship is upright causes it to continue rolling – States that, in the absence of other disturbing forces, the ship will roll to an angle where the sum of the energy used in overcoming resistance to rolling and the dynamical stability are equal to the rotational energy when upright – States that a beam wind exerts a force equal to the wind pressure multiplied by the projected lateral area of the portion of the ship and deck cargo above the waterline – Explains that a heeling moment is formed, equal to the force of the wind multiplied by the vertical separation between the centres of the lateral areas of the portions of the ship above and below the waterline – States that the heeling lever equals the heeling moment divided by the ship's displacement – States that a steady wind will cause a ship to heel to an angle at which the righting lever is equal to the heeling over – States that a ship under the action of a steady wind would roll about the resulting angle of heel – On a curve of righting levers, indicates the angle of equilibrium under the action of a steady wind and	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		the areas which represent the dynamical stability at angles of roll to each side of the equilibrium position by reference to dynamical stability, describes the effect of an increase in wind pressure when a vessel is at its maximum angle of roll to windward – Summarizes the recommendation on severe wind and rolling criterion for the intact stability of passenger and cargo ships – By reference to a curve of righting levers and dynamical stability, describes the effect of a listing moment on the rolling of the ship about the equilibrium position <u>Approximate GM by Means of Rolling Period Test</u> – States that, for ships up to 70m in length, the GM can be verified in still water by causing the ship to roll and noting the rolling period – Defines the rolling period as the time taken for one complete oscillation from the extreme end of a roll to one side, right across to the extreme on the other side and back to the original position – States that for small angles of roll in still water, the initial metacentric height, GMo is given by: $GM_o = [fB / Tr]^2$ Where: f = rolling factor B = breadth of the ship Tr = rolling period in seconds – States that the formula may be given as: $GM_o = F / Tr^2$ Where the F-value is provided by the Administration – Summarizes the procedures for determining a ship's stability by means of the rolling period test – Given values of F and T and the equation GMo = F / T^2, calculates GM_o	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		– States the limitations of the method – States the limitations of the method states that when construction is completed, a ship undergoes an inclining test to determine the displacement and position of the centre of gravity, KG and LCG, in the light ship condition – States that the displacement and KM are calculated from the observed draughts and the ship‘s lines plans, making allowance for density of water and trim – States that the position of the centre of buoyancy is calculated to enable the LCG for the light ship to be determined – Describes how an inclining test is carded out – Given the mass and the distance through which it was moved, the displacement, length of the plumb line and the deflection, calculates the KG – States that the values obtained in a test are corrected for masses to be removed and added to obtain the KG and LCG for the light ship – States that, at periodical intervals not exceeding five years, a light ship survey must be carried out on all passenger ships to verify any changes in light ship displacement and longitudinal centre of gravity – States that the ship must be re-inclined whenever, in comparison with the approved stability information, a deviation from the light ship displacement exceeding 2% or a deviation of the longitudinal centre of gravity exceeding 1% of L is found or anticipated <u>The Intact Stability Code</u> – Describes the general precautions to be taken against capsizing	

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		– States the recommended criteria for passenger and cargo ships of all types
		– Given the initial metacentric height and the GZ curve, determines whether the ship meets the recommended criteria
		– States that stability information should comprise:
		  – stability characteristics of typical loading conditions
		  – information to enable the master to assess the stability of the ship in all loading conditions differing from the standard ones
		  – information on the proper use of anti-rolling devices, if fitted
		  – information enabling the master to determine GMo by means of a rolling test corrections to be made to GMo for free surface liquids
		  – for ships carrying timber deck cargoes information setting out changes in deck cargo from that shown in the loading conditions, when the permeability of the deck cargo is significantly different from 25%
		  – for ships carrying timber deck cargoes, indications of the maximum permissible amount of deck cargo
		– States that criteria are laid down for ships carrying timber deck cargoes
		– Discusses the use of the weather criterion and how to assess whether a vessel complies with this
		– States the additional criteria recommended for passenger ships
		– States that the information includes a curve or table giving, as a function of the draught, the required initial GM which ensures compliance with the recommendations on intact stability
		
		Intact Stability Requirements for the Carriage of Grain	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS

		– States the intact stability requirements for the carriage of grain
		– States that before loading bulk grain the master may be required to demonstrate that the ship will comply with the stability criteria at all stages of the voyage
		– States that the ship must be upright before proceeding to sea
		– States that grain loading information includes:
		  – curves or tables of grain heeling moments for every compartment, whether filled or partly filled
		  – tables of maximum permissible heeling moments or other information sufficient to allow the master to demonstrate compliance with the requirements
		  – details of the requirements for temporary fittings and the provisions for the bundling of bulk grain
		  – typical loaded service departure and arrival conditions and, where necessary, intermediate worst service conditions
		  – a worked example for the guidance of the master
		  – loading instructions in the form of notes summarizing the requirements of SOLAS, chapter VI
		– Explains what are volumetric heeling moments
		– States that heeling moment = volumetric heeling moment / stowage factor
		– States how the vertical shift of grain surfaces is taken into account in filled compartments and in partly filled compartments
		– Calculates the heeling arm, λ_O, from:
		$\lambda_O = \frac{\text{Volumetric heeling moment}}{\text{(stowage factor x displacement)}}$	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		– Draws the heeling-arm curve on the righting-arm curve for a given ship and KG, corrected for free surface liquid, and: – determines the angle of heel – using Simpson's rules, calculates the residual dynamical stability to the angle laid down by Regulation 4 of SOLAS chapter VI – Compares the results of the calculations in the above objective with the criteria set out in Regulation 4 and states whether the ship complies with the requirements or does not comply <u>Rolling of Ships</u> – Describes the effect on GM of rolling – Explains how increase of draught and of displacement influence rolling – Describes how the distribution of mass within the ship affects the rolling period – Explains what synchronization is and the circumstances in which it is most likely to occur – Describes the actions to take if synchronization is experienced – Describes how bilge keels, anti-rolling tanks and stabilizer fins reduce the amplitude of rolling – States that a ship generally heels when turning – States that, while turning, the ship is subject to an acceleration towards the centre of the turn – States that the force producing the acceleration acts at the underwater centre of lateral resistance, which is situated at about half-draught above the keel – States that the force in the above objective is called the centripetal force, given by: $F = Mv^2 / r$ Where: M = mass of the ship in tonnes v = speed in metres per second	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		r= radius of turn in metres F = centripetal force in kilonewtons – Explains how the force acting at the centre of lateral resistance can be replaced by an equal force acting through the centre of gravity and a heeling couple equal to the force x vertical separation between the centre of lateral resistance and the centre of gravity, $\frac{Mv^2}{r}\left(KG - \frac{d}{2}\right)\cos\theta$ – States that the ship will heel until the resulting righting moment equals the heeling couple, i.e $M \times g \times GM \sin\theta = \frac{Mv^2}{r}\left(KG - \frac{d}{2}\right)\cos\theta$ where: g = acceleration due to gravity θ = angle of heel Given the relevant data, calculates the angle of heel from $\tan\theta = \frac{v^2 \times \left(KG - \frac{d}{2}\right)}{g \times GM \times r}$ Dry-docking and Grounding – States that for dry-docking a ship should: – have adequate initial metacentric height – be upright – have a small or moderate trim, normally by the stern – States that part of the weight is taken by the blocks as soon as the ship touches, reducing the buoyancy force by the same amount – States that the upthrust at the stern causes a virtual loss of metacentric height – Explains why the GM must remain positive until the critical instant at which the ship takes the blocks overall	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		– Derives the formula for the upthrust at the stern $P = \frac{(MCT \times t)}{L}$ where: P = upthrust at the stern in tonnes t = change of trim in cm L = distance of the centre of flotation from aft – Explains that a ship with a large trim will develop a large upthrust, which may damage the stern frame, trip the blocks or lead to an unstable condition before taking the blocks overall – By taking moments about the centre of buoyancy, shows that, for a small angle of heel, θ, righting moment= Δ x GM sin θ - P x KM sin θ where GM is the initial metacentric height when afloat – Shows that the righting lever is that for the ship with its metacentric height reduced by: $\frac{(P \times KM)}{\Delta}$ – By using the equation in the above objective and KM + KG + GM, shows that righting moment = (Δ - P) x GM sin θ - P x KG sin θ – Shows that the righting lever is that for a ship of displacement (Δ - P) and with metacentric height reduced by: $\frac{(P \times KG)}{\Delta - P}$ – Explains that the righting moment remains positive providing Δ x GM is greater than P x KM or equivalently, (Δ - P) x GM is greater than P x KG – Calculates the minimum GM to ensure that the ship remains stable at the point of taking the blocks overall – Calculates the maximum trim to ensure that the ship remains stable on taking the blocks overall for a given GM	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		– Calculates the virtual loss of GM and the draughts of the ship after the after level has fallen by a stated amount – Calculates the draughts on taking the blocks overall – Explains that the stability of a ship aground at one point on the centre line is reduced in the same way as in dry-docking – States that when grounding occurs at an off-centre point, the upthrust causes heel as well as trim and reduction of GM – Explains that the increase in upthrust as the tide falls increases the heeling moment and reduces the stability <u>Shear Force, Bending Moments and Torsional Stress</u> – Explains what is meant by shearing stress – States that the shear force at a given point of a simply supported beam is equal to the algebraic sum of the forces to one side of that point – Explains that, for a beam in equilibrium, the sum of forces to one side of a point is equal to the sum of the forces on the other side with the sign reversed – Explains what is meant by a bending moment – States that the bending moment at a given point of a beam is the algebraic sum of the moment of force acting to one side of that point – States that the bending moment measured to opposite sides of a point are numerically equal but opposite in sense – Draws a diagram of shear force and bending moment for simply supported beams – States that the bending moment at any given point is equal to the area under the shear-force curve to that point	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		– Uses the above objective to show that the bending-moment curve has a turning point where the shear force has zero value – Explains that shear forces and bending moments arise from differences between weight and buoyancy per unit length of the ship – States that the differences between buoyancy and weight is called the load – Draws a load curve from a given buoyancy curve and weight curve – States that the shear force at any given point is equal to the area under the load curve between the origin and that point – Draws a diagram of shear force and bending moment for a given distribution of weight for a box-shaped vessel – Explains how wave profile affects the shear-force curve and bending-moment curve – States that each ship above a specified length is required to carry a loading manual, in which are set out acceptable loading patterns to keep shear forces and bending moments within acceptable limits – States that the classification society may also require a ship to carry an approved means of calculating shear forces and bending moment at stipulated stations – Demonstrates the use of a loading instrument – States that the loading manual and instrument, where provided, should be used to ensure that shear forces and bending moments do not exceed the permissible limits in still water during cargo and ballast handling – Explains what is meant by a torsional stress – Describes how torsional stresses in the hull are set up	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		– States that wave-induced torsional stresses are allowed for in the design of the ship – States that cargo-induced torsional stresses are a problem mainly in container ships – States that classification societies specify maximum permissible torsional moments at a number of specified cargo bays – Given details of loading, calculates cumulative torsional moments for stated positions – Describes the likelihood of overstressing the hull structure when loading certain bulk cargoes	

	Knowledge of the effect on trim and stability of a ship in the event of damage to and consequent flooding of a compartment and countermeasures to be taken	Effect on trim and stability of a ship in the event of damage to and consequent flooding of a compartment and countermeasures to be taken
		
		Passenger Vessels
		
		– Explains what is meant by ‘floodable length‘
		– Defines:
		  – margin line
		  – bulkhead deck
		  – permeability of a space
		– Explains what is meant by permissible length of compartments‘ in passenger ships
		– Describes briefly the significance of the Criterion of Service Numeral
		– Explains the significance of the factor of subdivision
		– States the assumed extent of damage used in assessing the stability of passenger ships in damaged condition
		– Summarises, with reference to the factor of subdivision, the extent of damage which a passenger ship should withstand
		– Describes the provisions for dealing with asymmetrical flooding
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COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS

		– States the requirements for the final condition of the ship after assumed damage and, where applicable, equalization of flooding
		– States that the master is supplied with data necessary to maintain sufficient intact stability to withstand the critical damage
		– Explains the minimum residual stability requirements in the damaged condition with the required number of compartments flooded
		– Discusses the use of the damaged stability information required to be provided to the Master of a passenger vessel
		
		Cargo Ships
		
		– Distinguishes between ships of Type A and Type B for the purpose of computation of freeboard
		– Describes the extent of damage that a Type A ship of over 150 m in length should be able to withstand
		– Explains that a Type A ship of over 150m in length is described as a one compartment ship
		– Describes the requirements for the survivability of Type B ships with reduced assigned freeboard
		– Summarises the equilibrium conditions regarded as satisfactory after flooding
		– States that damage to compartments may cause a ship to sink as a result of :
		  – insufficient reserve buoyancy leading to progressive flooding
		  – progressive flooding due to excessive list or trim
		  – capsizing due to a loss of stability
		  – structural failure
		Calculation of Vessel Condition After Flooding
		
		– States that, in the absence of hull damage, the stability is calculated in the usual way using the	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		added mass and making allowance for free surface liquid – States that free surface moments for any rectangular compartment that is flooded by salt water can be approximated by moment = length x $(\text{breadth})^3$ x 1. 025 / 12 – States that virtual loss of GM = $\frac{\text{moment}}{\text{flooded displacement}}$ – States that when a compartment is holed the ship will sink deeper in the water until the intact volume displaces water equivalent to the mass of the ship and its contents – Explains that the loss of buoyancy of a holed compartment is equal to the mass of water which enters the compartment up to the original waterline – States that the volume of lost buoyancy for a loaded compartment is equal to the volume of the compartment x the permeability of the compartment – Calculates the permeability of cargo, given its density and its stowage factor – States that if the lost buoyancy is greater than the reserve buoyancy the ship will sink – States that the centre of buoyancy moves to the centre of immersed volume of the intact portion of the ship – States that when a compartment is holed the ship's displacement and its centre of gravity are unchanged – Explains that a heeling arm is produced, equal to the transverse separation of G and the new position of B for the upright ship – States that the area of intact waterplane is reduced by the area of the flooded spaces at the level of	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		the flooded waterline multiplied by the permeability of the space – States that if the flooded space is entirely below the waterline there is no reduction in intact waterplane – Calculates the increase in mean draught of a ship, given the TPC and the dimensions of the flooded space, using: increase in draught = $\frac{\text{volume of lost buoyancy}}{\text{area of intact waterplane}}$ – States that the height of the centre of buoyancy above the keel increases by about half the increase in draught due to flooding – States that a reduction in waterplane area leads to a reduction in the second moment of area (I) – Uses the formula BM = I / V to explain why the BM of a ship is generally less when bilged that when intact – States that change in GM is the net result of changes in KB and BM – Explains why the GM usually decreases where: — there is a large loss of intact waterplane — there is intact buoyancy below the flooded space — the flooded surface has a high permeability – Explains why the bilging of empty double-bottom tanks or of deep tanks that are wholly below the waterline leads to an increase in GM – Calculates the reduction in BM resulting from lost area of the waterplane, given the following corrections: — second moment of lost area about its centroid / displaced volume; this is $\frac{lb^3}{12V}$ for a rectangular surface where: L is length of the lost area b is breadth of the lost area	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		V is displaced volume = displacement / density of water original waterplane area / intact waterplane area x lost area x (distance from centerline)^2 / displaced volume this is original waterplane area / intact waterplane area x l.b.d^2 / V for a rectangular surface, where d is the distance of the centre of the area from the centreline – Deduces that the second correction applies only in the case of asymmetrical flooding – Calculates the shift (F) of the centre of flotation (CE) from the centreline, using $F = \frac{a \times d}{A - a}$ where: a is the lost area of waterplane A is the original waterplane area d is the distance of the centre of lost area of waterplane from the centerline – Shows that the heeling arm is given by – heeling arm = lost buoyancy (tonnes) / displacement x transverse distance from new CF – Constructs a GZ curve for the estimated GM and superimposes the heeling-arm curve to determine the approximate angle of heel – Uses wall sided formula to determine GZ values – Uses wall sided formula to calculate angle of heel – States that, for small angles of heel, θ, $\tan \theta = \frac{\text{heeling arm}}{GM}$ – Explains how lost area of waterplane affects the position of the centre of flotation Effect of Flooding on Trim	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		– Calculates the movement of the centre of flotation (CF), given: – Movement of CF = moment of lost area about original CF / intact waterplane area – Explains how the reduction in intact waterplane reduces the MCT 1cm – Calculates the reduction of BML, given the following corrections: – second moment of lost area about its centroids/ displaced volume; this is $\frac{bL^3}{12\ V}$ for a rectangular surface where: L is length of lost area B is breadth of lost area V is displaced volume = $\frac{\text{displacement}}{\text{density of water}}$ – Original waterplane area / intact waterplane area x lost area x (distance from CF) ^{2} / displaced volume – This is original waterplane area / intact waterplane area x bld^2 / v – For a rectangular surface, where d is the distance of the centre of area from the original centre of flotation – Calculates the reduction of MCT 1cm, given, reduction of MCT 1 cm = (displacement x reduction of GM) / 100 x ship‘s length – States that the trimming moment is calculated from: – trimming moment = lost buoyancy x distance from new CF where the lost buoyancy is measured in tonnes – Given the dimensions of a bilged space and the ship‘s hydrostatic data, calculates the draughts in the damaged condition describes measures which may be taken to improve the stability or trim of a damaged ship	

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
	Knowledge of the effect on trim and stability of a ship in the event of damage to and consequent flooding of a compartment and countermeasures to be taken	Theories Affecting Trim and Stability – Describes the static and dynamic effects on stability of liquids with a free surface centre of gravity of slack tanks – Identifies free surface moments and shows its application to dead-weight moment curves – Interprets changes in stability which take place during a voyage – Describes effect on stability of ice formation on superstructure – Describes the effect of water absorption by deck cargo and retention of water on deck – Describes stability requirements for dry docking – Demonstrates understanding of angle of loll – States precautions to be observed in correction of angle of loll – Explains the dangers to a vessel at an angle of loll – Describes effects of wind and waves on ships stability – Lists the main factors which affect the rolling period of a vessel – Explains the terms synchronous and parametric rolling and pitching and describes the dangers associated with it – Describes the actions that can be taken to stop synchronous and parametric effects	2
	Knowledge of IMO recommendations concerning ship stability	Responsibilities under the relevant requirement of the International Conventions and Codes – States minimum stability requirements required by Load Line Rules 1966	2

COMPETENCE	KNOWLEDGE, UNDERSTANDING AND PROFICIENCY	TOPICS	APPROX HOURS
		– States the minimum stability requirements and recommendations of the Intact Stability Code – Explains the use of the weather criterion – Demonstrates correct use of IMO Grain Regulations – Explains how grain heeling moment information is used – Describes the requirements for passenger ship stability after damage	
		TOTAL	96