



**UNIVERSITI KUALA LUMPUR**  
**Malaysian Institute of Marine Engineering Technology**

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**FINAL EXAMINATION**  
**JULY 2025 SEMESTER SESSION**

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<b>SUBJECT CODE</b>	<b>: LMB31203</b>
<b>SUBJECT TITLE</b>	<b>: RESISTANCE AND PROPULSION</b>
<b>PROGRAMME NAME</b> (FOR MPU: PROGRAMME LEVEL)	<b>: BACHELOR OF MARINE ENGINEERING TECHNOLOGY WITH HONOURS</b>
<b>TIME / DURATION</b>	<b>: 2.00 PM – 4.30 PM (2 HOURS 30 MINUTES)</b>
<b>DATE</b>	<b>: 16 DECEMBER 2025</b>

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**INSTRUCTIONS TO CANDIDATES**

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1. Please read **CAREFULLY** the instructions given in the question paper.
2. This question paper consists of **TWO (2) sections**, Section A and Section B.
3. Answer **ALL** questions in Section A. For Section B, answer **THREE (3) question ONLY**.
4. Please write your answers on the answer booklet provided.
5. Answer all **FIVE (5)** questions in English language **ONLY**.
6. The formula and charts have been appended to use.

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**THERE ARE 3 PAGES OF QUESTIONS, EXCLUDING THIS PAGE.**

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**SECTION A (Total: 40 marks)**

**INSTRUCTION: Answer ALL questions.**

**Please use the answer booklet provided.**

**Question 1**

With reference to introduction to design and flow phenomena and motion of ship:

- a) In dealing with ship design concept by Evans (1959), illustrate the process through a simplified sketch of 'Design Spiral' and label at least **SIX (6)** distinct stages/considerations in its iterative process.

(8 marks)

- b) In dealing with 'Boundary Layer (BL)' concept defined by Prandtl, explain **THREE (3)** characteristics identified around a solid body moving through a fluid based on the following distinct flow areas:

i. Inside the BL

(6 marks)

ii. Outside the BL

(6 marks)

**Question 2**

With reference to ship resistance and model testing:

- a) Illustrate with a simple sketch, a typical towing tank setup for resistance model experiments, labelling at least **FOUR (4)** key features (towing tank, towing carriage, model, dynamometer).

(12 marks)

- b) In dealing with ship model testing,

i. Explain the term 'blockage effects'

(4 marks)

ii. Describe **TWO (2)** criteria considered to avoid 'blockage effects' (tank wall interference) when selecting a ship model for testing in a towing tank.

(4 marks)

**SECTION B (Total: 60 marks)**

**INSTRUCTION: Answer ONLY THREE (3) questions.**

**Please use the answer booklet provided.**

**Question 3**

With reference to marine propeller and propulsion:

- a) In dealing with the blade element theory, apply the following elements of vector sum:
- i. Velocity components (2 marks)
  - ii. Hydrodynamic pitch angle (2 marks)
  - iii. Geometric pitch angle (2 marks)
  - iv. Angle of Attack (AoA) (2 marks)
- b) Explain **SIX (6)** reasons the geometric angle of a propeller blade section (relative to the plane of rotation) must change with increasing radius from the hub in maintaining a relatively constant angle of attack (AoA), assuming constant pitch (P) and uniform inflow velocity ( $V_A$ ). (12 marks)

**Question 4**

With reference to propeller design using charts and polynomials:

A containership is to be designed to travel at 20 knots. The total resistance of the ship at full scale is 2015kN. The propeller with 4.2m diameter, comprise of five blades and having a blade area ratio of 0.85. Using the B-series k-J chart provided for this blade area ratio, calculate the required pitch to diameter ratio of these screws, the propeller RPM, and the efficiency at which they will operate. To calculate this, you must tabulate J and  $K_Q$  values using the  $K_Q - J^3$  relationship of  $K_Q = 0.528J^5$ , assuming the wake fraction value to be 0.22.

(20 marks)

**Question 5**

With reference to propeller design using charts and polynomials ( $B_P - \delta$  chart):

A product tanker, designed for a Port Kuantan - Shanghai route is to have a vessel speed of 15 knots. Early resistance prediction reveals that the vessel will be installed with a 12600 kW diesel propulsion motor. The propeller is set to 90 RPM. Using the  $B_{P1-\delta}$  chart for propeller Wageningen B4.100 and assuming the shafting efficiency to be 0.985, calculate the improved propeller diameter, pitch-diameter ratio, and the resulting open water efficiency of propeller. Assume the following values:  $w = 0.23$ .

(20 marks)

**Question 6**

With reference to Propeller Cavitation considerations:

A 16 knots (advance velocity) regular gas tanker with  $P_D = 10010$  kW is to be equipped with propeller diameter of 5 m and shaft revolution of 105 rpm, with propeller shaft axis immersion of 5 m and the developed area of the propeller blade is  $11.5\text{m}^2$ . Using Burrill's cavitation diagram, determine its cavitation status. Assume the following values for thrust deduction factor of 0.18, wake fraction of 0.21, pitch-diameter ratio of 0.9, open water efficiency of 0.59 and relative rotative efficiency of 0.97.

(20 marks)

**END OF QUESTION PAPER**



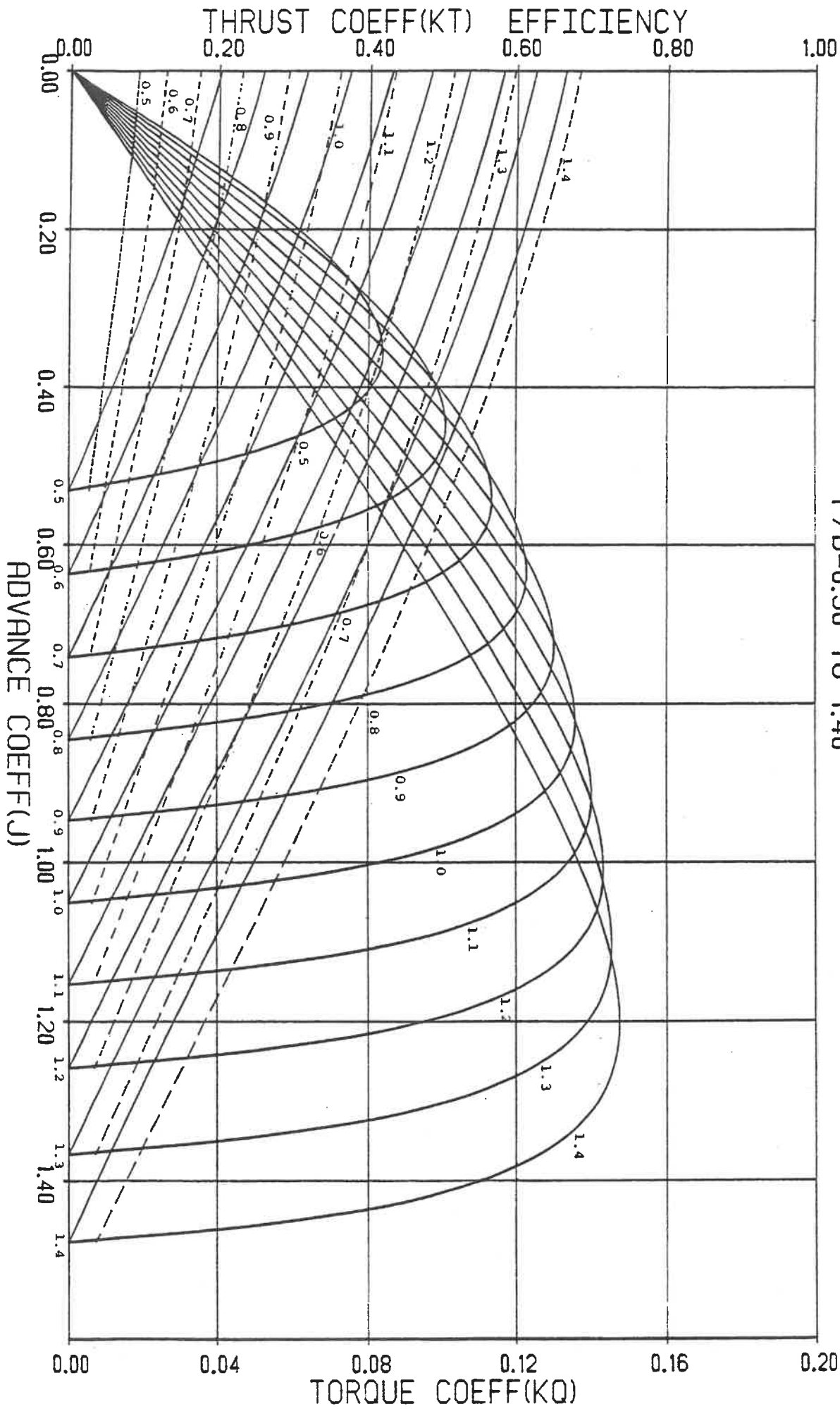
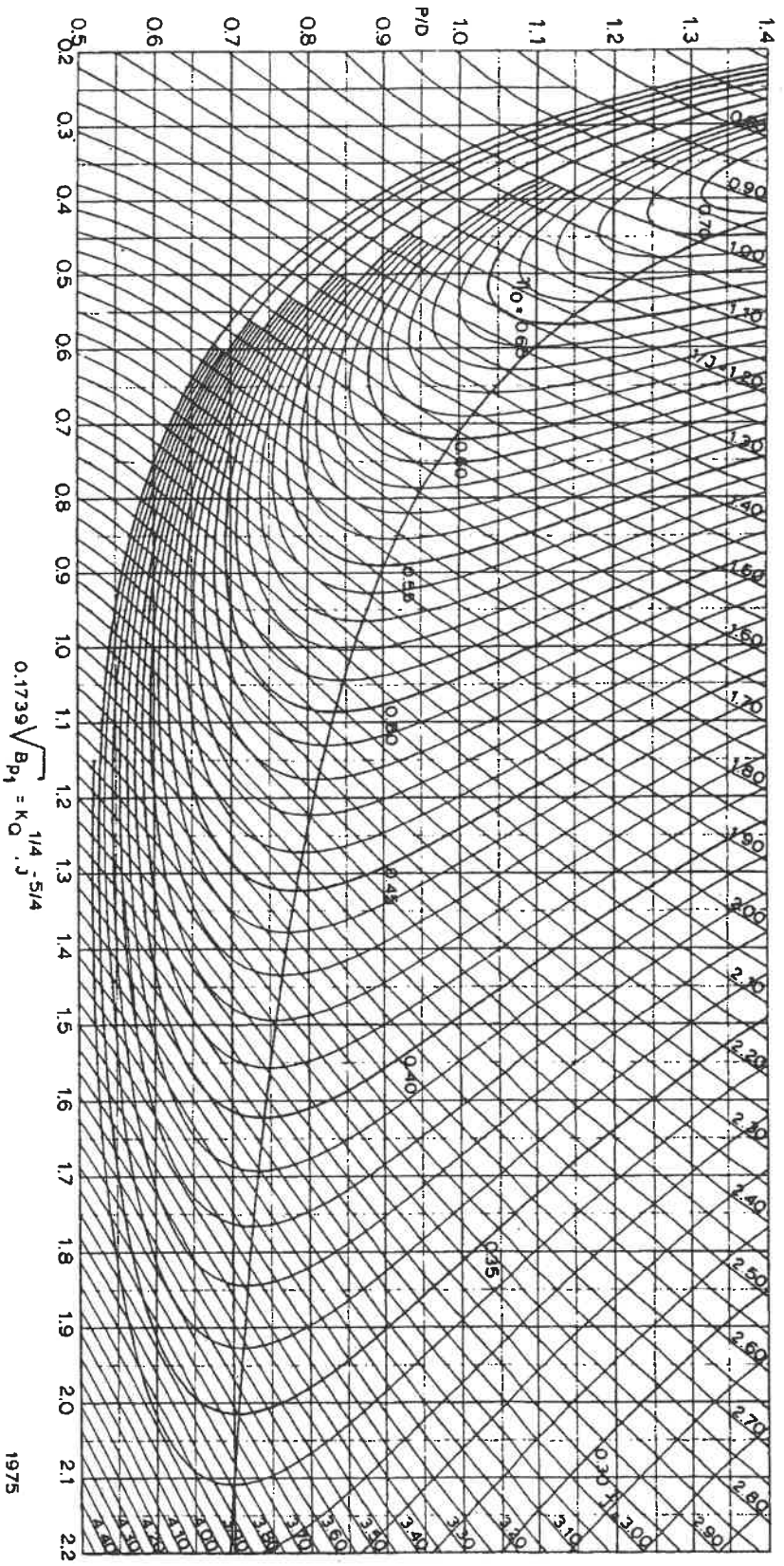


FIGURE 60. WAGENINGEN B-SERIES PROPELLERS  
 FOR 5 BLADES AE/A0 = 0.850  
 P/D=0.50 TO 1.40





B4 - 100

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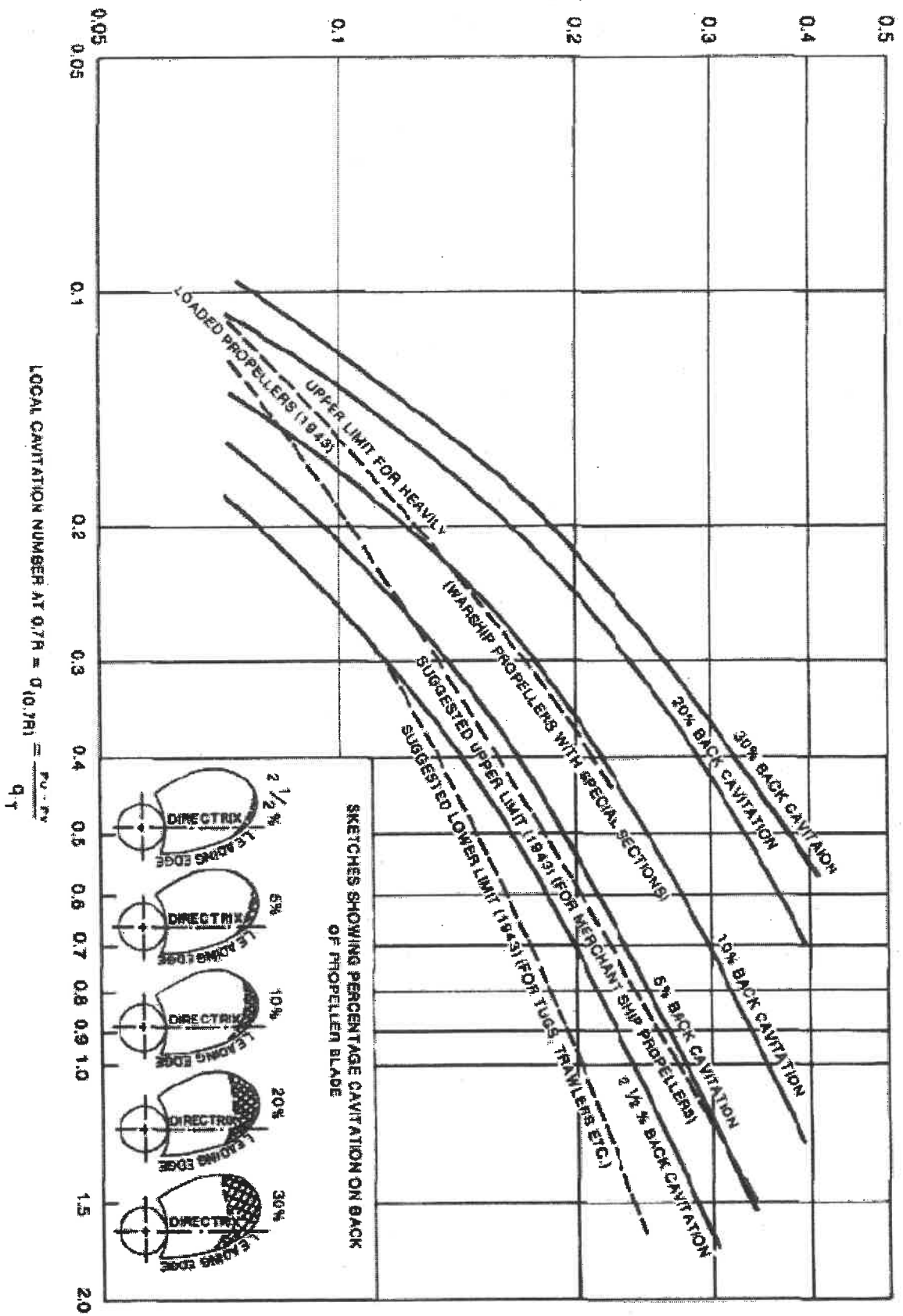
$B_{p1} = N^2 \cdot V_A^{-5/2}$   
 N = PROPELLER RPM  
 $V_A = V_S (1-w)$   
 $V_S$  = SHIP SPEED IN KNOTS  
 w = WAKE FRACTION  
 P = SHAFT HORSEPOWER (BRITISH)

$K_Q \cdot J^{1/4} = \left[ \frac{Q \cdot n^3}{p \cdot V_A^5} \right]^{1/4}$   
 Q = PROPELLER TORQUE IN KGM  
 n = PROPELLER REVOLUTIONS PER SECOND  
 p = WATER DENSITY (TANK) = 101.94 KG/SEC<sup>2</sup> M<sup>-4</sup>  
 $V_A = V_S (1-w)$   
 $V_S$  = SHIP SPEED IN M/SEC.  
 w = WAKE FRACTION

Fig. 56



$$\tau_c = \frac{T}{1/2 \rho A_p V^2 R(0.7)}$$





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**USEFUL FORMULA & DATA**

**Density**

Fresh water	= 1000 kg/m <sup>3</sup>
Sea water	= 1025 kg/m <sup>3</sup>
Air at 15°C	= 1.225 kg/m <sup>3</sup>

**Kinematic viscosity**

Fresh water at 15°C	= 1.139 x 10 <sup>-6</sup> m <sup>2</sup> /s
Sea water at 15°C	= 1.183 x 10 <sup>-6</sup> m <sup>2</sup> /s
Fresh water at 24°C	= 9.131 x 10 <sup>-7</sup> m <sup>2</sup> /s

**Granville Line Formulation**

$$C_{FO} = \frac{0.0776}{(\log_{10} Re - 1.88)^2} + \frac{60}{Re}$$

**Hughes Line Formulation**

$$C_{FO} = \frac{0.066}{(\log_{10} Re - 2.03)^2}$$

**ATTC Line Formulation**

$$\frac{0.242}{\sqrt{C_F}} = \log_{10}(Re \cdot C_F)$$

**ITTC 1957 Model Ship Correlation Formulation**

$$C_F = \frac{0.075}{(\log_{10} Re - 2)^2}$$

**Non-dimensional coefficient for total resistance**

$$C_T = \frac{R_T}{\frac{1}{2} \rho S V^2}$$

**Froude's approach**

$$R_T = R_F + R_R$$

$$C_T = C_F + C_R$$

**Hughes's approach**

$$R_T = R_V + R_W$$

$$C_T = C_V + C_W$$

$$= C_F(1+k) + C_W$$

**ITTC 1978 Resistance Prediction – Updated 2014**

The total ship resistance coefficient without bilge keels is given by;

$$C_{TS} = C_{FS}(1+k) + C_R + \Delta C_F + C_A + C_{AAS}$$

where;

$C_{FS}$  = frictional coefficient of ship according to the ITTC 1957 ship model correlation line

$C_R$  = residual resistance calculated from the total and viscous resistance of the model

$$= C_{TM} - (1+k)C_{FM}$$

Bilge keels can be allowed for by multiplying the  $C_{FS}$  and  $C_A$  terms by the ratio

$$\frac{S + S_{BK}}{S}, S_{BK} = \text{surface area of the bilge keels}$$

The correlation allowance is calculated from

$$C_A = (5.68 - 0.61 \log Re) \times 10^{-03}$$

The roughness allowance is calculated from

$$\Delta C_F = 0.044 \left[ \left( \frac{k_s}{L_{WL}} \right)^{\frac{1}{3}} - 10 \cdot Re^{-\frac{1}{3}} \right] + 0.000125$$

$k_s$  can be taken as 150 x 10<sup>-6</sup> m.

Air resistance is calculated from

$$C_{AAS} = C_{DA} \frac{\rho_A \cdot A_{VS}}{\rho_S \cdot S_S}$$

$A_{VS}$  = transverse projected area of ship above the waterline

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**Propeller scale effect correction**

$$K_{TOS} = K_{TO} - \Delta K_T$$

$$K_{QOS} = K_{QO} - \Delta K_Q$$

$$\Delta K_T = -\Delta C_D \times 0.3 \frac{P}{D} \cdot \frac{cZ}{D}$$

$$\Delta K_Q = \Delta C_D \times 0.25 \frac{cZ}{D}$$

$$\Delta C_D = C_{DM} - C_{DS}$$

$$C_{DM} = 2 \left( 1 + 2 \frac{t}{c} \right) \left[ \frac{0.044}{R_{nco}^{1/6}} - \frac{5}{R_{nco}^{2/3}} \right]$$

$$C_{DS} = 2 \left( 1 + 2 \frac{t}{c} \right) \left[ 1.89 + 1.62 \log_{10} \frac{c}{k_p} \right]^{-2.5}$$

$$k_p = 30 \times 10^{-6} m$$

$$R_{nco} = \frac{c \sqrt{V_A^2 + (2\pi r)^2}}{v}$$

**Emerson Blockage correction**

$$\frac{\Delta V}{V} = 1.65 \frac{m_3}{1 - m_3 - F_{nh}^2}$$

$$m_1 = \frac{A_M}{A}$$

$$m_2 = \frac{\nabla}{A \times L}$$

$$m_3 = \frac{m_1 + m_2}{2}$$

$$F_{nh} = \frac{V}{\sqrt{gh}}$$

$A_M$  : midship sectional area f model

$A$  : tank cross sectional area

$\nabla$  : model volume displacement

$L$  : model length

$V$  : model speed before correction

**Schuster Blockage correction**

$$\frac{\Delta V}{V} = \frac{m_1}{1 - m_1 - F_{nh}^2} + \left( 1 - \frac{R_V}{R_T} \right) \cdot \frac{2}{3} \cdot F_{nh}^{10}$$

$$m_1 = \frac{A_M}{A_T}$$

where  $A_M$  is the maximum sectional area of the model and  $A_T$  is the maximum sectional area of the full scale vessel.

**Ship Flow of Transmission of Power**

$$P_E = R_T V_S$$

$$P_T = T V_A$$

$$K_T = \frac{T}{\rho n^2 D^4}$$

$$K_Q = \frac{Q}{\rho n^2 D^5}$$

$$J = \frac{V_A}{nD}$$

$$\eta_O = \frac{K_T}{K_Q} \cdot \frac{J}{2\pi}$$

$$\eta_H = \frac{P_E}{P_T} = \frac{R_T V_S}{T V_A}$$

$$\eta_s = \frac{P_D}{P_B}$$

$$\eta_B = \frac{P_T}{P_D}$$

$$\eta_D = QPC = \frac{P_E}{P_D} = \eta_R \eta_O \eta_H = \frac{(1-t)}{(1-w)} \eta_B$$

$$\text{Propeller Torque } Q = \frac{P_D}{2\pi n}$$

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Propeller Thrust  $T = \frac{P_T}{V_A}$

$\eta_R = \frac{\eta_B}{\eta_O} = \frac{P_T}{P_D} \cdot \frac{P_{DO}}{P_{TO}}$

Thrust identity;  $P_T = P_{TO}$ ;  $\therefore \eta_R = \frac{P_{DO}}{P_D}$

Torque identity;  $P_D = P_{DO}$ ;  $\therefore \eta_R = \frac{P_T}{P_{TO}}$

$\frac{P_E}{P_B} = \eta_S \eta_R \eta_O \eta_H$

$t = \frac{T - R_T}{T}$  or  $\frac{R_T}{T} = 1 - t$

$\omega = \frac{V_S - V_A}{V_S}$  or  $\frac{V_A}{V_S} = 1 - \omega$

Apparent Slip =  $\left(1 - \frac{V}{Pn}\right)$

True Propeller Slip =  $\left(1 - \frac{V_A}{Pn}\right)$

**Propeller Design using Charts and Polynomials**

Known power, RPM and advance velocity

$\frac{K_Q}{J^3} = \frac{Q}{\rho n^2 D^5} \left(\frac{nD}{V_A}\right)^3 = \frac{Qn^3}{\rho V_A^3}$

Known power, diameter and advance velocity

$\frac{K_Q}{J^3} = \frac{Q}{\rho n^2 D^5} \left(\frac{nD}{V_A}\right)^3 = \frac{Qn}{\rho D^2 V_A^3} = \frac{P_D}{2\pi \rho D^2 V_A^3}$

Known thrust, diameter and advance velocity

$\frac{K_T}{J^2} = \frac{T}{\rho n^2 D^4} \left(\frac{nD}{V_A}\right)^2 = \frac{T}{\rho V_A^2 D^2}$

Known thrust, RPM and advance velocity

$\frac{K_T}{J^4} = \frac{T}{\rho n^2 D^4} \left(\frac{nD}{V_A}\right)^4 = \frac{Tn^2}{\rho V_A^4}$

**Cavitation Considerations**

**Burrill's Method**

$V_R = \left[ (0.7\pi nD)^2 + V_A^2 \right]^{\frac{1}{2}}$

$P_O = P_{atm} + \rho gh$

Atmospheric pressure

$P_{atm} = 101300 \text{ N/m}^2$

Vapour pressure of water

$P_V = 1700 \text{ N/m}^2$  at 15°C

$\sigma = \frac{P_O - P_V}{q_T}$

$q_T = 0.5 \rho V_R^2$

$\frac{A_P}{A_D} = \left[ 1.067 - 0.229 \frac{P}{D} \right]$

$\tau_c = \frac{T}{\frac{1}{2} \rho A_P V_R^{(0.7)}}$

**Keller's method**

$\frac{A_E}{A_O} = \frac{(1.3 + 0.3Z)T}{(P_O - P_V)D^2} + K$

