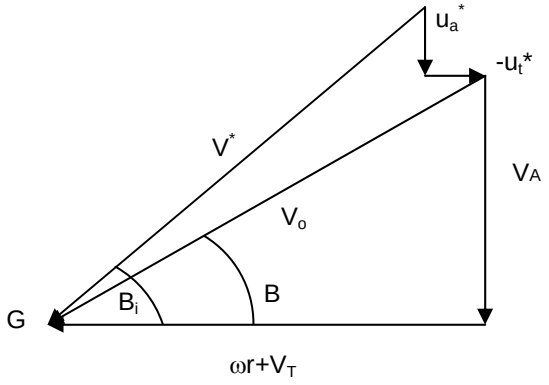
Massachusetts Institute of Technology
DEPARTMENT OF MECHANICAL ENGINEERING
Center of Ocean Engineering

2.611 SHIP POWER and PROPULSION
Fall 2006, Quiz 1

1) (20 pts)

   a) Discuss how Controllable Reversible Pitch (CRP) propellers can help prevent engine overloading. Consider your answer in terms of Torque (Q), angle of attack (α), Lift, Drag, Velocity of Advance (J), Pitch, and shaft speed. (The use of all terms is not necessary as long as a logical sound argument is made.) (10pts)

   b) Discuss the cause of u_a and u_t.



2) (50 pts) A ship captain must purchase a new propeller to replace the damaged one currently installed on his ship. The supplier only has two propellers in stock. Both are fixed pitch, 5 blade Wageningen B-series propeller with an EAR of .45, one has a pitch of 17.1 ft and the other a pitch of 20.9 ft. The details of the ship are as follows:

Ship and Propeller characteristics:
B-series 5-45 propeller (see attached sheet)
$Pitch_1$ = 17.1 ft or $Pitch_2$ = 20.9 ft
Diameter = 19 ft
Wake Reduction Factor, w = .2
Thrust Reduction Factor, t = .12
Relative Rotative Efficiency, η_R = 0.89
Ship Resistance at max Power, 174800 lbf
Velocity of the ship = 20 kts

Conversion factors

$$\text{knot} = 1.688 \ \frac{\text{ft}}{\text{sec}}$$

$$\rho := 1.9905\,\text{lbf}\cdot\frac{\text{sec}^2}{\text{ft}^4}$$

a) Using the provided Wageningen B-Series design curves, determine the best choice between the two propellers in stock with respect to efficiency η_o. (J^2 function, η_o, and correct choice – 20 pts)

b) Determine $J_{optimum}$, $K_{Toptimum}$, $K_{Qoptimum}$ (15 pts)

c) Determine the Optimal propeller speed n_p. (5pts)

d) Calculate Thrust (T) and Torque (Q) (5pts)

e) The ship's engines are capable or producing 16 x 10^3 HP, will the ships engines be adequate for propeller selected? (5pts)

3) (30 pts) The same Captain asks you to design a new propeller for his pleasure boat. You run PVL and get the following results at r/R=.7:

Given:
r/R = .7
Nprop = 220 rpm
D = 1 m
Va = 18 m/s
Vt = 0 m/s
Ut* = -.9 m/s
Ua* = .9 m/s
G = .7 m^2/s
c = .18 m
w = 0

a) Draw the inflow vector diagram at .7R (10 pts)
b) Find V* (10 pts)
   i) Hint: $\omega = 2*pi*N$
c) What is C_L? (5 pts)
d) How do we determine if the blade will cavitate? No calculations are required. You can describe or use formulas. You do not have enough information to calculate a number for this blade. (5pts)