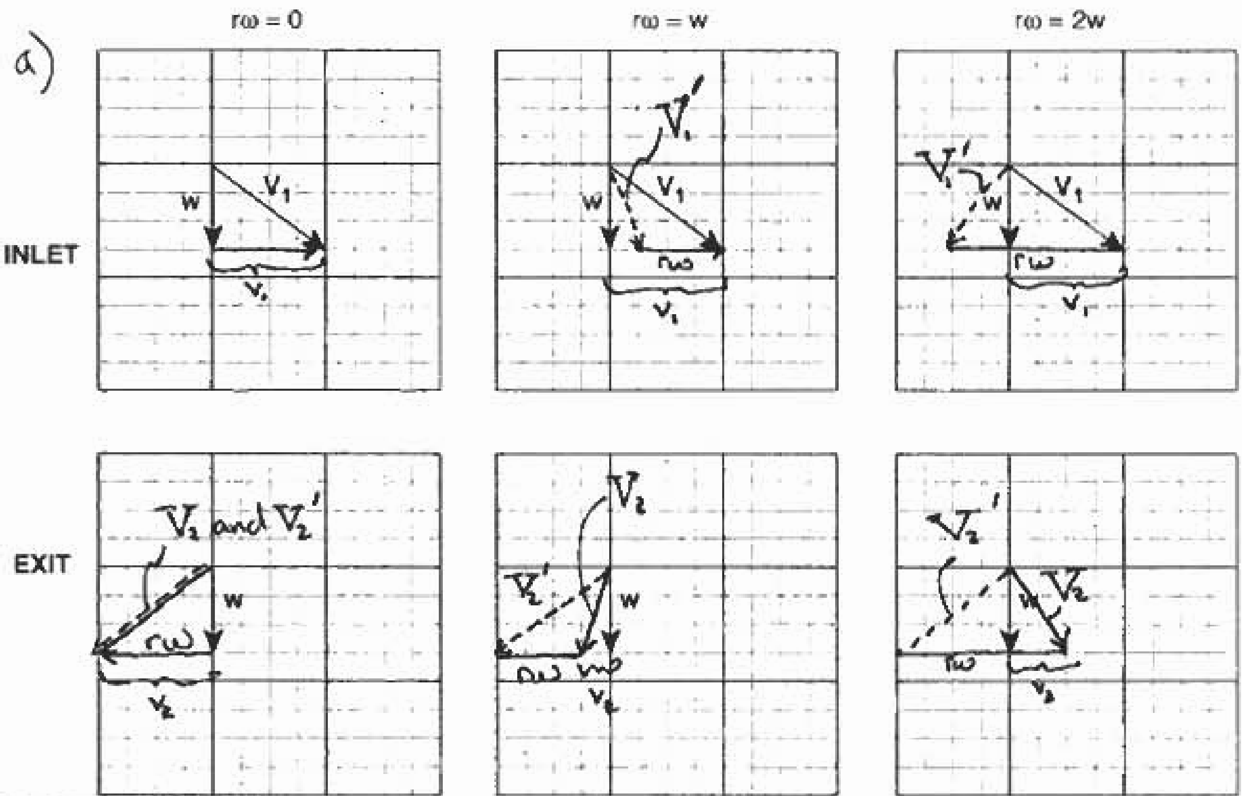
UNIFIED PROPULSION P9 SOLUTIONS WAITZ 2001

a)



b) $r\omega = W$ EXTRACTS THE MOST POWER. IT LEAVES THE LEAST SWIRLING KINETIC ENERGY IN THE FLOW $(\sim V_2^2)$ (OF THE 3 CASES SHOWN ABOVE)

c) <u>ARGUMENT 1:</u> IF $r\omega = \frac{4}{3} W$ ALL SWIRLING KINETIC ENERGY IS EXTRACTED (i.e. $v_2 = 0$). CAN SEE THIS FROM LOOKING AT THE GRAPHS.

<u>ARGUMENT 2:</u> TAKE DERIVATIVE OF EULER EQUATION w.r.t. $r\omega$ & SET $= 0$

$$\frac{d}{d(r\omega)}\left[(\omega r)W\tan\beta_1 + (\omega r)W\tan\beta_2' - (\omega r)^2\right] = 0 \quad \text{WITH } \beta_1 = \beta_2'$$

$$2W\tan\beta_1 = 2\omega r \quad \therefore \ \omega r = W\tan\beta_1$$

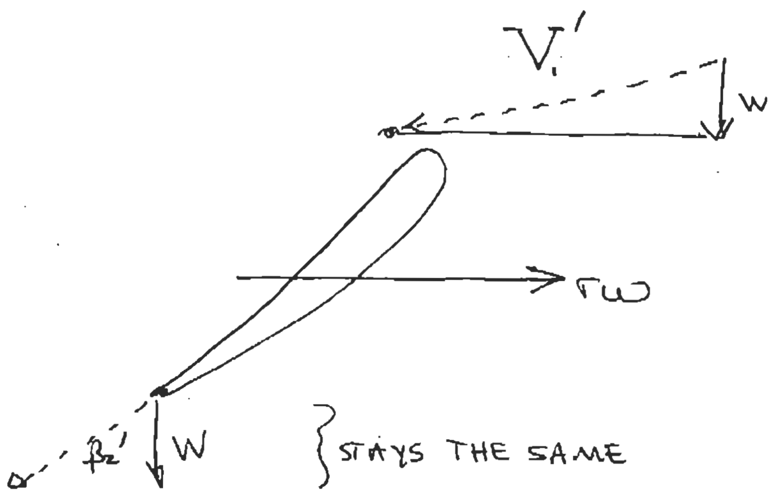
$$= W\frac{v_1}{W} = v_1$$

$$= \frac{4}{3}W \ \checkmark$$

d) IT BEGINS TO ACT LIKE A COMPRESSOR WHEN IT PUTS MORE SWIRL KINETIC ENERGY INTO FLOW ($\sim V_2^2$) THAN IT STARTED WITH ($\sim V_1^2$).

THIS HAPPENS (GRAPHICALLY) FOR $r\omega > 8/3\ W$, WHICH IS ALSO WHEN THE EULER TURBINE EQUATION STARTS GIVING NEGATIVE VALUES OF $T_{T_1} - T_{T_2}$, IMPLYING AN ENTHALPY RISE NOT AN ENTHALPY DROP.

REGARDING THE AERODYNAMICS FOR THIS SITUATION, CONSIDER THE RELATIVE FRAME VELOCITIES



NEGATIVE ANGLE OF ATTACK! (USUALLY DOESN'T WORK WELL)