P5 SOLUTIONS — WAITE

TO FIND MAX THRUST, USE $P_{avail} - P_{reqd} = \frac{d}{dt} P.E. + \frac{d}{dt} K.E.$
AND SOLVE FOR T FOR EACH OF
THE THREE MANEUVERS — THEN PICK THE BIGGEST ONE.

$$TV - DV = W\frac{dh}{dt} + \frac{d}{dt}\left(\frac{1}{2}\frac{W}{g}V^2\right)$$

CASE 1) 6g COMBAT TURN $\therefore \frac{dh}{dt} = 0$, $\frac{d}{dt}V^2 = 0$

$T = D$, $L = 9W$ $\quad D = \frac{1}{2}\rho V^2 S k C_L^2 + \frac{1}{2}\rho V^2 S C_{D_0}$

$$\frac{T}{W} = \frac{1}{2}\rho V^2\left(\frac{1}{W/S}\right)k\frac{L^2}{\left(\frac{1}{2}\rho V^2 S\right)^2} + \frac{1}{2}\rho V^2\left(\frac{1}{W/S}\right)C_{D_0}$$

$$\frac{T}{W} = \underbrace{\frac{kn^2}{\frac{1}{2}\rho V^2}\left(\frac{W}{S}\right)}_{3.18} + \underbrace{\frac{C_{D_0}}{\left(\frac{W}{S}\right)}\frac{1}{2}\rho V^2}_{0.0227}$$

$V = 0.7(295\,m/s) = 206.5$
$\rho = 0.34\ kg/m^3$
$k = 0.2$
$C_{D_0} = 0.01$
$n = 6$
$W/S = 3200\ N/m^2$

$3.2 = \frac{T}{W}$

$\therefore T = (3.2)(20{,}000)(9.8)$

$T = 627.2\,kN$

CASE 2) M=0.8 TO M=2.0 IN 15 SECONDS

$V_{FINAL} = 2(295\,m/s) = 590\,m/s$
$V_{initial} = 0.8(295\,m/s) = 236\,m/s$

$$\frac{\Delta V}{\Delta t} = \frac{590\,m/s - 236\,m/s}{15\,s} = 23.6\,\frac{m}{s^2} = \frac{dV}{dt}$$

$$\frac{T}{W} = \frac{kn^2}{\frac{1}{2}\rho V^2}\left(\frac{W}{S}\right) + \frac{C_{D_0}}{\left(\frac{W}{S}\right)}\frac{1}{2}\rho V^2 + \frac{1}{g}\frac{d}{dt}\left(\frac{1}{2}\frac{V^2}{g}\right)$$

$n = 1$

TRY WORST CASE FOR V & k & C_{D_0} @ M = 2

$$\frac{T}{W} = \underbrace{\frac{k}{\frac{1}{2}\rho V^2}\left(\frac{W}{S}\right)}_{0.022} + \underbrace{\frac{C_{D_0}}{\left(\frac{W}{S}\right)}\frac{1}{2}\rho V^2}_{0.481} + \underbrace{\frac{1}{g}\frac{dV}{dt}}_{2.41}$$

$k = 0.4$
$C_{D_0} = 0.026$
$V = 590\ m/s$
$\frac{W}{S} = 3200\ N/m^2$
$\rho = 0.34\ kg/m^3$

$\Rightarrow \frac{T}{W} = 2.91 \quad \therefore T = (2.91)(9.8)(20{,}000)$

$$\boxed{T = 570.3\ kN}$$

CASE 3) STRAIGHTUP AT M = 0.5

$$\frac{T}{W} = \frac{k}{\frac{1}{2}\rho V^2}\left(\frac{W}{S}\right) + \frac{C_{D_0}}{\left(\frac{W}{S}\right)}\frac{1}{2}\rho V^2 + \frac{1}{W V}\left(W\frac{dh}{dt}\right)$$

& $\frac{dh}{dt} = V$ SO $\frac{T}{W} = \underbrace{\frac{k}{\frac{1}{2}\rho V^2}\left(\frac{W}{S}\right)}_{0.182} + \underbrace{\frac{C_{D_0}}{\left(\frac{W}{S}\right)}\frac{1}{2}\rho V^2}_{0.0116} + 1$

$V = 0.5(295\ m/s) = 147.5\ m/s$
$W/S = 3200\ N/m^2$, $\rho = 0.34$, $k = 0.21$, $C_{D_0} = 0.01$

$\frac{T}{W} = 1.19 \quad \therefore T = 9.8 \cdot 20{,}000\,(1.19) = \boxed{233.9\ kN}$

$\therefore$ SIZE ENGINE FOR MAX = 627 kN