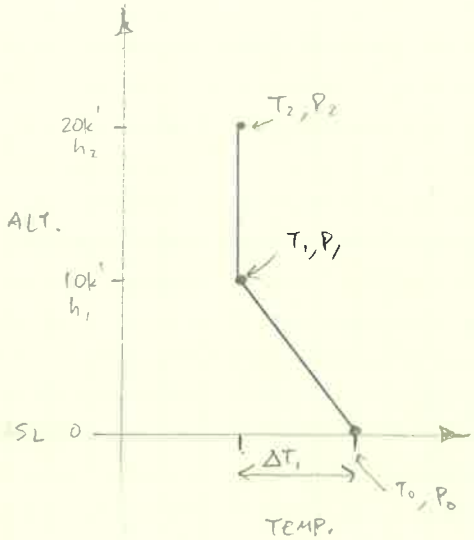
1. **GIVEN:** ALT. = 20,000 ft

$P_0 = 30.14$ in·Hg

$T_0 = 90°F$

$\lambda = \begin{cases} -0.005 \text{ R/ft}, & h < 10,000 \text{ ft} \\ 0, & h \geq 10,000 \text{ ft} \end{cases}$



FIND: ρ AT 20,000 ft

ASSUME: 1. AIR BEHAVES AS IDEAL GAS
2. GRAVITY ACCELERATION IS CONSTANT

SOL'N: $T_0 = 90 + 459.67 = 549.67$ R

$\Delta T_1 = T_1 \lambda = (10,000)(-0.005) = -50$ R

$T_1 = T_0 + \Delta T_1 = 549.67 - 50$

$T_1 = T_2 = 499.67$ R

$g_0 = 32.174$ ft/s²

$R = 1,716.5$ ft²/R·s²

$$P_1 = P_0\left(\frac{T_1}{T_0}\right)^{-g_0/R\lambda} = 30.14\left(\frac{499.67}{549.67}\right)^{\frac{-32.174}{(1,716.5)(-0.005)}}$$

$P_1 = 21.08$ in·Hg

$$P_2 = P_1 \exp\left[\frac{-g_0(h_2-h_1)}{RT_1}\right] = 21.08 \exp\left[\frac{-32.174(20,000-10,000)}{(1716.5)(499.67)}\right]$$

$$P_2 = 14.48 \text{ in·Hg} \left| \frac{70.726 \text{ lb}_f/\text{ft}^2}{\text{in·Hg}} \right.$$

$P_2 = 1,024.42$ lb$_f$/ft²

$$\rho = \frac{P_2}{RT_2} = \frac{1024}{(1716.5)(499.67)}$$

$\rho = 0.0012$ slug/ft³ ✓ 1/1

~~4~~ 10/10 Co

2. GIVEN: NACA 0012

$R_e > 10E+6$

FIND: C_L, C_D, C_M AT AOA = 10°

SOL'N: APPENDIX IV, THEORY OF WING SECTIONS

$C_L = 1.1$
$C_M = 0.275$
$C_D = 0.010$

1/1

FIND: $C_{L,MAX}$

SOL'N: $C_{l,max} = 1.5$ / 1/1

- LIFT AND MOMENT COEFFICIENTS REACH A MAXIMUM AND STEEPLY DECLINE AFTER STALL ANGLE / 4/4

3. GIVEN: 1:10 SCALE MODEL
STD. SEA LEVEL CONDITIONS
AIR AS TEST FLUID

FIND: P TO MATCH Re AND Ma

ASSUME: $P_{atm}(SSL) = 14.696$ psi
→ ASSUME AIR ACTS AS IDEAL GAS

SOL'N: $Ma_o = Ma_m$

$$\left(\frac{V}{a}\right)_o = \left(\frac{V}{a}\right)_m$$

a IS CONSTANT FOR AIR
$\therefore V_o = V_m$

$Re_o = Re_m$

$$\left(\frac{\rho V L}{\mu}\right)_o = \left(\frac{\rho V L}{\mu}\right)_m$$

μ IS CONSTANT FOR AIR
$\therefore \mu_o = \mu_m$

$L_o = 10 L_m$

$\rho_o L_o = \rho_m L_m$

$10 \rho_o L_m = \rho_m L_m$

$10 \rho_o = \rho_m$

$\rho = \frac{P}{RT}$

$\frac{10 P_o}{RT} = \frac{P_m}{RT}$

$P_o = P_{atm} = 14.696$

$P_m = 10 \cdot 14.696$

$\boxed{P_m = 146.96 \text{ psi}}$ / $\frac{1}{1}$

GIVEN: $\rho_w = 1000 \rho_{AIR}$

FIND: IF A WATER TUNNEL CAN MATCH BOTH Ma AND Re

SOL'N: a FOR WATER IS MUCH HIGHER (1482 m/s @ 20°C) THAN AIR (343 m/s @ SSL) SO A HIGHER CHANGE IN VELOCITY IS REQUIRED TO MATCH Ma NUMBER, SO THE WATER TUNNEL VELOCITY MUST BE REDUCED.

THE VISCOSITY OF AIR IS ABOUT 18x HIGHER THAN WATER (1.75 E-5 Pa/m² vs 1.00E-6 Pa/m² @ 20°C)

IN ORDER TO USE THE WATER TUNNEL TO MATCH Re, THE SCALE OF THE MODEL MUST BE GREATLY REDUCED Quantify? $\frac{1}{1}$

4. GIVEN: CESSNA 182

$S = 174\ ft^2$

$P = 230\ HP$

$W = 3{,}100\ lb_f$

FIND: $C_{L,MAX}$ IF $V_{STALL} = 49$ knots

ASSUME: $\rho(SSL) = 0.00237\ slug/ft^3$

SOL'N: $L = W = 3{,}100\ lb_f$

$V_S = 49\ \text{knots} \cdot \frac{1.6878\ ft/s}{\text{knot}} = 82.70\ ft/s$

$C_{L,MAX} = \frac{2L}{\rho V_S^2 S} = \frac{2(3100)}{(0.00237)(82.7^2)(174)}$? 1/1

$\boxed{C_{L,MAX} = 2.2}$ / 4

FIND: η_{PROP} IF $V_{CRUISE} = 145$ knots AND $C_D = 0.025 + 0.054\, C_L^2$

SOL'N: $V_C = 145\ \text{knots} \cdot \frac{1.6878\ ft/s}{\text{knots}} = 244.73\ ft/s$

$C_L = \frac{2L}{\rho V_C^2 S} = \frac{2(3100)}{(0.00237)(244^2)(174)} = 0.251$ / 1/1

$C_D = 0.025 + 0.054(0.251^2) = 0.0284$

$D = \frac{1}{2}\rho V_C^2 C_D S = \frac{1}{2}(0.00237)(244^2)(0.028)(174) = 350.76\ lb_f$ /

$P_{AIR} = D \cdot V_C = (350.76)(244.73) = 85{,}840.9\ ft \cdot lb_f/s$

$P_{AIR} = 85{,}840.9\ lb \cdot ft/s \cdot \frac{0.001818\ HP}{lb_f \cdot ft/s} = 156.06\ HP$ / 1/1

$\eta_{PROP} = \frac{P_{AIR}}{P_{PROP}} = \frac{156.06}{230} = 0.6785$ ✓ 60

$\boxed{\eta_{PROP} = 67.9\%}$ X ~~72.9%~~ 0/1

5 ~~4~~