11.36

GIVEN: HIGH SPEED TRAIN OF PROBLEM 9.69. $C_{D,FORM} = 0.80$ AND TOTAL FORCE TO OVERCOME BEARING RESISTANCE IS 3000 N.

$A_p = 9\,m^2$, $V_{01} = 100$ km/HR AND $V_{02} = 200$ km/HR.

FIND: TOTAL RESISTANCE OF TRAIN.

% DUE TO BEARINGS, FORM DRAG, AND SKIN FRICTION DRAG.

SOLUTION: SKIN FRICTION DRAG WAS CALCULATED IN PROBLEM 9.72

(a) $F_{S1} = 1353$ N

(b) $F_{S2} = 5006$ N

FORM DRAG $F_{D,FORM} = C_{D,FORM}\left(\frac{1}{2}\rho V_0^2\right) A_p$

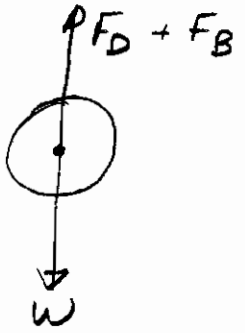
$T = 10°C$, $\rho = 1.25 \frac{kg}{m^3}$, AND $A_p = 9\,m^2$

(a) $F_{DF1} = 3472$ N

(b) $F_{DF2} = 13889$ N

	V_0	F_{TOT}	% BEARINGS	% FORM	% S.F.
(a)	100 km/HR	7,825 N	38%	45%	17%
(b)	200 km/HR	21,895 N	14%	63%	23%

11.45 (1)



GIVEN: 0.5 cm HAILSTONE FALLS IN AIR AT 96 kPa ABSOLUTE AT 0°C, $\gamma = 6\ kN/m^3$

FIND: TERMINAL VELOCITY

SOLUTION: $\sum F_z = 0$ $\quad F_D + \cancel{F_B}^{\text{NEGLECT}} - W = 0$

$F_D = W \qquad \frac{1}{2}\rho_{AIR} V_0^2 C_D A_p = \gamma \forall$

$$V_0 = \sqrt{\frac{2\gamma \forall}{\rho_{AIR} C_D A_p}}$$

$$\rho_{AIR} = \frac{96{,}000}{(287)(273)}$$

$$\rho_{AIR} = 1.225 \frac{kg}{m^3}$$

$$V_0 = \sqrt{\frac{2\gamma \frac{4}{3}\pi r^3}{\rho_{AIR} C_D \pi r^2}}$$

$$V_0 = \sqrt{\frac{8\gamma r}{3\rho_{AIR} C_D}}$$

GUESS $C_D = 1$, $\quad V_0 = \sqrt{\frac{8(6000)(.0025)}{3(1.225)\ 1}}$

$V_0 = 5.7\ m/s$, $\quad Re = \frac{(.005)(5.7)}{1.33 \times 10^{-5}} = 2148$

ENTER FIGURE 11.11 WITH $Re = 2148$

FIND $C_D \approx 0.4$

11.45 (2)

FIND V_0 WITH $C_D = 0.4$

$V_0 = 9.0$ m/s $\approx$ 20 MPH

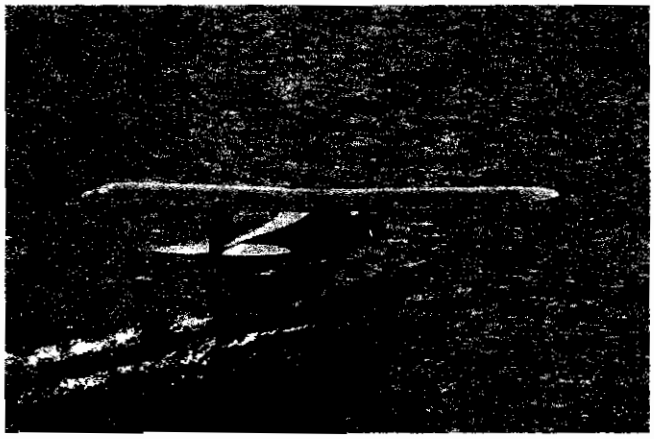
PIPER (1)

PIPER J-3 "CUB"

FIRST PROTOTYPE COMPLETED IN 1938

COST ≃ $1000

WINGSPAN ~ 35' 3"



WING AREA ~ 178.5 FT^2

MAX TAKEOFF WEIGHT ~ 1220 LB_f

POWERPLANT ~ CONTINENTAL FLAT FOUR ~ 65 HP

MAX SPEED ~ 75 MPH

GIVEN: R.C. MODEL OF PIPER J-3

$L = 61"$ AND $C = 9"$

FIND: (a) SCALE OF MODEL

(b) MAX LIFT FORCE OF MODEL AT 50 MPH

(c) DRAG FORCE AND POWER REQUIRED AT MAX LIFT AT 50 MPH

PIPER (2)

(a) $\frac{L_m}{L_p} = \frac{61''}{423''} = .144 \simeq \frac{1}{7}$ SCALE

CHECK WING AREA SCALE

$A_m = \frac{61 \cdot 9}{144} = 3.81 \text{ FT}^2$

$\frac{A_m}{A_p} = \frac{3.81}{178.5} = .0214$

$\left(\frac{L_m}{L_p}\right)^2 = .144^2 = .0207$

VERY CLOSE

(b) $F_L = \frac{1}{2} \rho V_0^2 C_L S$

USE FIGURE 11.23 TO OBTAIN C_L

ASPECT RATIO : $\Lambda = \frac{b}{C} = \frac{L}{C}$

$\Lambda = \frac{61}{9} = 6.8 \Rightarrow$ USE $\Lambda = 7$ CURVE

ON FIGURE 11.23. MAXIMUM C_L IS APPROXIMATELY 1.15.

$\rho = .00237 \frac{\text{SLUGS}}{\text{FT}^3}$ @ 60°F & SEA LEVEL

$F_L = \frac{1}{2}(.00237)(50)^2\left(\frac{5280}{3600}\right)^2(1.15)\left(\frac{9}{12}\right)\left(\frac{61}{12}\right)$

$F_L = 27.9 \text{ LB}_f$

PIPER (3)

NOTE THAT F_L SHOULD SCALE BY WING AREA RATIO

$\frac{27.9}{.0214} = 1306$ LBf WHICH IS CLOSE TO MAX TAKEOFF WEIGHT SPECIFICATION OF 1220 LBf.

(c) $F_D = \frac{1}{2} \rho V_0^2 C_D S$

FIGURE 11.23, $\Lambda = 7$ CURVE

$\Rightarrow C_D \approx 0.11$

$F_D = 2.67$ LBf

$P = F_D V_0 = 2.67 (50) \left(\frac{5280}{3600}\right)$

$P = 196 \frac{FT\text{-}LBf}{S} = 0.36$ hp

HOW WILL POWER SCALE?