9.70*

9.70 The helium-filled balloon shown in Fig. P9.70 is to be used as a wind speed indicator. The specific weight of the helium is $\gamma = 0.011$ lb/ft^3, the weight of the balloon material is 0.20 lb, and the weight of the anchoring cable is negligible. Plot a graph of θ as a function of U for $1 \le U \le 50$ mph. Would this be an effective device over the range of U indicated? Explain.

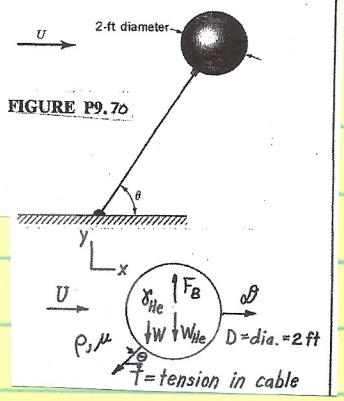


FIGURE P9.70

$\rho = .00238$ slug/ft^3 $\quad \forall = \frac{4}{3}\pi R^2$

$\gamma = 7.65 \times 10^{-2}$ lb/ft^3 $\quad A_p = \pi R^2$

(1) $\Sigma F_x = 0$ $\qquad \Sigma F_y = 0$

$D = T \cos\theta$ $\qquad F_B = W + T\sin\theta + W_{He}$

$T = D/\cos\theta$

(2) combine $\quad D\tan\theta = F_B - W - W_{He}$

$\tan\theta = (F_B - W - W_{He})/D$

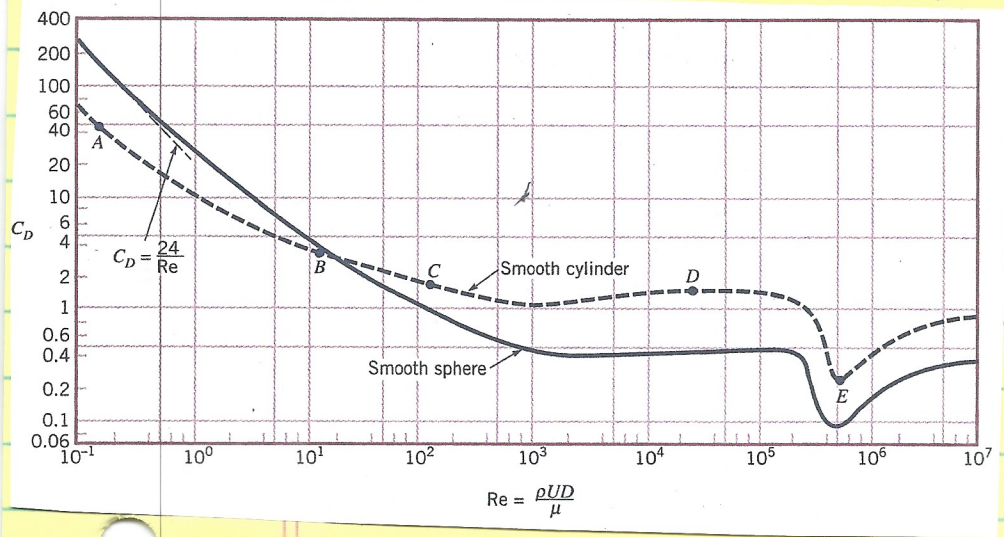
$F_B = \rho g \forall = .321$ lb $\quad W_{He} = \gamma_{He}\forall = .0461$ lb $\quad W = .2$ lb

$D = \frac{1}{2}\rho U^2 A_p C_D(Re)$

$= .00374\, U^2 C_D(Re)$ $\quad Re = UD/\nu = 1.27 \times 10^4 U$

(4) $\tan\theta = (.32 - .2 - .0461)/.00374\, U^2 C_D(Re)$

$= 19.9/U^2 C_D(Re)$ $\quad$ plot $\theta = f(U)$ →



U, mph	Re	CD	Θ, deg
0	0	---	90
1	12700	0.40	87.52
2	25400	0.42	79.71
5	63500	0.54	34.42
10	127000	0.55	9.55
15	190500	0.33	7.10
20	254000	0.10	13.02
25	317500	0.08	10.48
30	381000	0.09	6.52
40	508000	0.12	2.76
50	635000	0.16	1.32

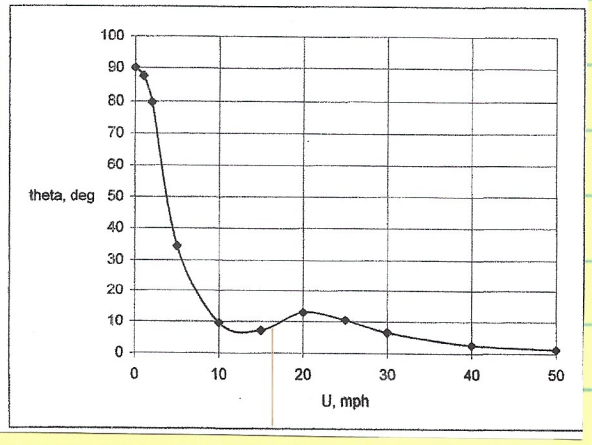
$0 \le U \le 50$ mph

$1.47 \le U \le 73.3$ ft/s

$Re = f(U)$

$C_D = f(Re)$

$\theta = f(C_D, U)$



$\theta = f(U)$ multi valued near

$U = 15$ ft/s due drag crisis

∴ does not work well as wind speed meter in this range