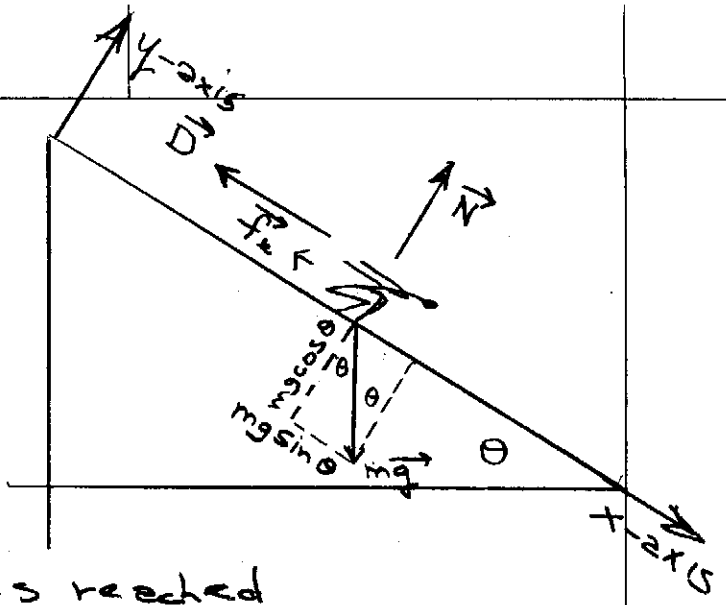
STAEDTLER® No. 937 811E Engineer's Computation Pad

••38 In downhill speed skiing a skier is retarded by both the air drag force on the body and the kinetic frictional force on the skis. (a) Suppose the slope angle is $\theta = 40.0°$, the snow is dry snow with a coefficient of kinetic friction $\mu_k = 0.0400$, the mass of the skier and equipment is $m = 85.0$ kg, the cross-sectional area of the (tucked) skier is $A = 1.30\ m^2$, the drag coefficient is $C = 0.150$, and the air density is $1.20\ kg/m^3$. (a) What is the terminal speed? (b) If a skier can vary C by a slight amount dC by adjusting, say, the hand positions, what is the corresponding variation in the terminal speed?



$$\vec{F}^{net}_{skier} = m_{skier}\vec{a}_{skier} \equiv 0$$

When Terminal Speed is reached

$$F_y^{net} \equiv 0 \Rightarrow N - mg\cos\theta = 0 \Rightarrow N = mg\cos\theta$$

$$F_x^{net} \equiv 0 \Rightarrow mg\sin\theta - f_k - D = 0$$

$$f_k = \mu_k N = \mu_k mg\cos\theta = (0.04)(85.0)(9.80)\cos 40° = 25.5\ N$$

$$D = \frac{1}{2}C\rho A v_T^2 = \frac{1}{2}(0.150)(1.20)(1.30)v_T^2 = 0.117 v_T^2\ N$$

$$F_x^{net} = 0 \Rightarrow D = \frac{1}{2}C\rho A v_T^2 = mg\sin\theta - \mu_k mg\cos\theta$$

$$\Rightarrow v_T = \sqrt{\frac{2mg}{C\rho A}(\sin\theta - \mu_k\cos\theta)}$$

$$v_T = \sqrt{\frac{2(85.0)(9.80)}{0.150(1.20)(1.30)}(0.643 - 0.04(0.766))} = 66.0\ m/s \quad (29.5\ mi/hr)$$

$$D = 0.117 v_T^2 = 510\ N \quad \& \quad mg\sin\theta = (85.0)(9.80)(0.643) = 535\ N$$

$$\frac{dv_T}{dC} = \frac{1}{2}\left[\frac{2mg}{C\rho A}(\sin\theta - \mu_k\cos\theta)\right]^{-1/2}\left[\frac{2mg}{\rho A}(\sin\theta - \mu_k\cos\theta)\right] * \left(-1C^{-2}\right) = \frac{-1}{2}\sqrt{\frac{2mg}{\rho A}(\sin\theta - \mu_k\cos\theta)}\left[C^{(1/2-2)} = C^{-3/2}\right]$$

OR SIMPLY WRITE $v_T = C^{-1/2}\sqrt{\frac{2mg}{\rho A}(\sin\theta - \mu_k\cos\theta)}$, THEN

$$\frac{dv_T}{dC} = \frac{-1}{2}C^{-3/2}\sqrt{\frac{2mg}{\rho A}(\sin\theta - \mu_k\cos\theta)}$$

$$dv_T = -\left(\frac{1}{2}\sqrt{\frac{2mg}{\rho A}(\sin\theta - \mu_k\cos\theta)}\right)\frac{dC}{C^{3/2}}$$

$$dv_T \propto \frac{-dC}{C^{3/2}}$$

$$dv_T = -\frac{1}{2}\frac{v_T}{C}dC$$

WOULD HIDE SOME OF THE C-DEPENDENCE



FIG. 6-6 This skier crouches in an "egg position" so as to minimize her effective cross-sectional area and thus minimize the air drag acting on her. *(Karl-Josef Hildenbrand/dpa/Landov LLC)*