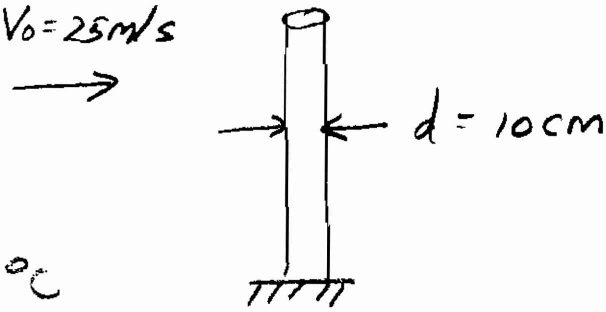
11.13



GIVEN: FLAG POLE AS SHOWN.

$p_0 = 100\ kPa$, $T_0 = 20°C$

FIND: VORTEX SHEDDING FREQUENCY

SOLUTION: CALCULATE REYNOLDS NUMBER AND USE FIGURE 11.10 TO FIND STROUHAL NUMBER.

$$Re = \frac{d V_0}{\nu} = \frac{(0.10)(25)}{1.51 \times 10^{-5}} = 1.7 \times 10^5$$

$$S = 0.21 = \frac{n d}{V_0}$$

$$n = \frac{S V_0}{d} = \frac{(0.21)(25\ \frac{m}{s})}{0.10\ m}$$

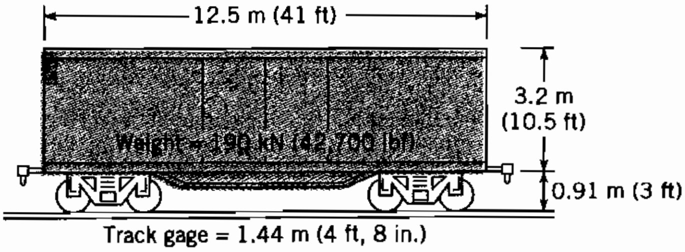
$$\boxed{n = 52\ HZ}$$

11.27

GIVEN: BOX CAR WITH DIMENSIONS AS SHOWN

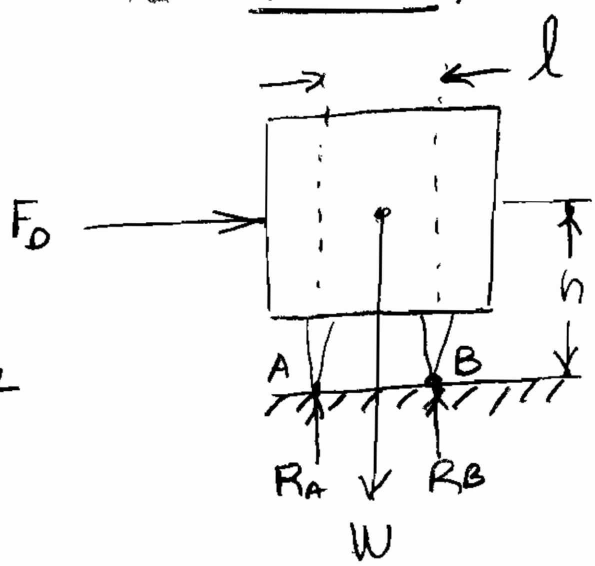
FIND: MINIMUM WIND SPEED TO BLOW OVER THE BOX CAR

11.27 Windstorms sometimes blow empty boxcars off their tracks. The dimensions of one type of boxcar are shown. What minimum wind velocity normal to the side of the car would be required to blow the car over?



PROBLEM 11.27

SOLUTION: DRAW F.B.D. OF BOX CAR AS SEEN FROM THE FRONT.



$$\sum M_B = 0$$

$$R_A \ell + F_D h - W\left(\frac{\ell}{2}\right) = 0$$

THE BOX CAR WILL START TO TIP WHEN $R_A \rightarrow 0$.

$$\Rightarrow \quad F_D = W \frac{\ell}{2h} \qquad \ell = 1.44 \text{ m} \qquad h = 2.51 \text{ m}$$

$$F_D = 190 \text{ kN} \; \frac{1.44 \text{ m}}{2(2.51 \text{ m})}$$

$$F_D = 54.5 \text{ kN}$$

11.27 (2)

$$F_D = \frac{1}{2} \rho V_0^2 C_D A_p$$

$$V_0 = \sqrt{\frac{2 F_D}{\rho C_D A_p}} \qquad \rho = 1.2 \frac{kg}{m^3}$$

TABLE 11.1

SQUARE ROD $\qquad C_D = 2.00$

USE THIS C_D TO ESTIMATE V_0.

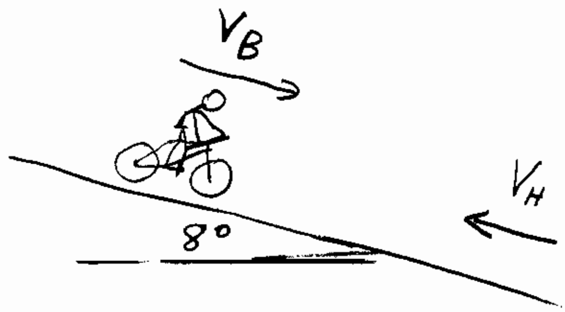
PUT MODEL BOXCAR IN WIND TUNNEL FOR TO IMPROVE THE CALCULATION.

$$V_0 = \sqrt{\frac{2(54{,}500)}{1.2 (2.00)(12.5)(3.2)}}$$

$$V_0 = 33.7 \text{ m/s} \approx 75 \text{ MPH}$$

11.28

GIVEN: BICYCLIST COASTING DOWN A HILL



$m = 80\,kg$ $\quad V_H = 5\,m/s$

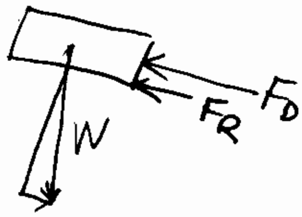
$C_D = 0.5$, $\rho = 1.2\ \frac{kg}{m^3}$, $A_P = .5\,m^2$

$C_R = 0.02$ ROLLING FRICTION COEFFICIENT

FIND: BICYCLE SPEED

SOLUTION: DRAW FREE BODY DIAGRAM

$W \sin\theta - F_R - F_D = 0$



$F_R = C_R W$ ROLLING RESISTANCE

$F_D = C_D \frac{1}{2} \rho V_0^2 A_p$

V_0 IS RELATIVE WIND $\quad V_0 = V_B + V_H$

$$C_D \frac{1}{2} \rho V_0^2 A_p = W \sin\theta - C_R W$$

$$V_0 = \sqrt{\frac{2W(\sin\theta - C_R)}{\rho C_D A_p}} = V_B + V_H$$

$$V_B = \sqrt{\frac{2(80)(9.8)(0.139 - .02)}{(1.2)(.5)(.5)}} - V_H$$

$$V_0 = 25.0\ \frac{m}{s} - 5.0\ \frac{m}{s} = 20.0\ \frac{m}{s}$$