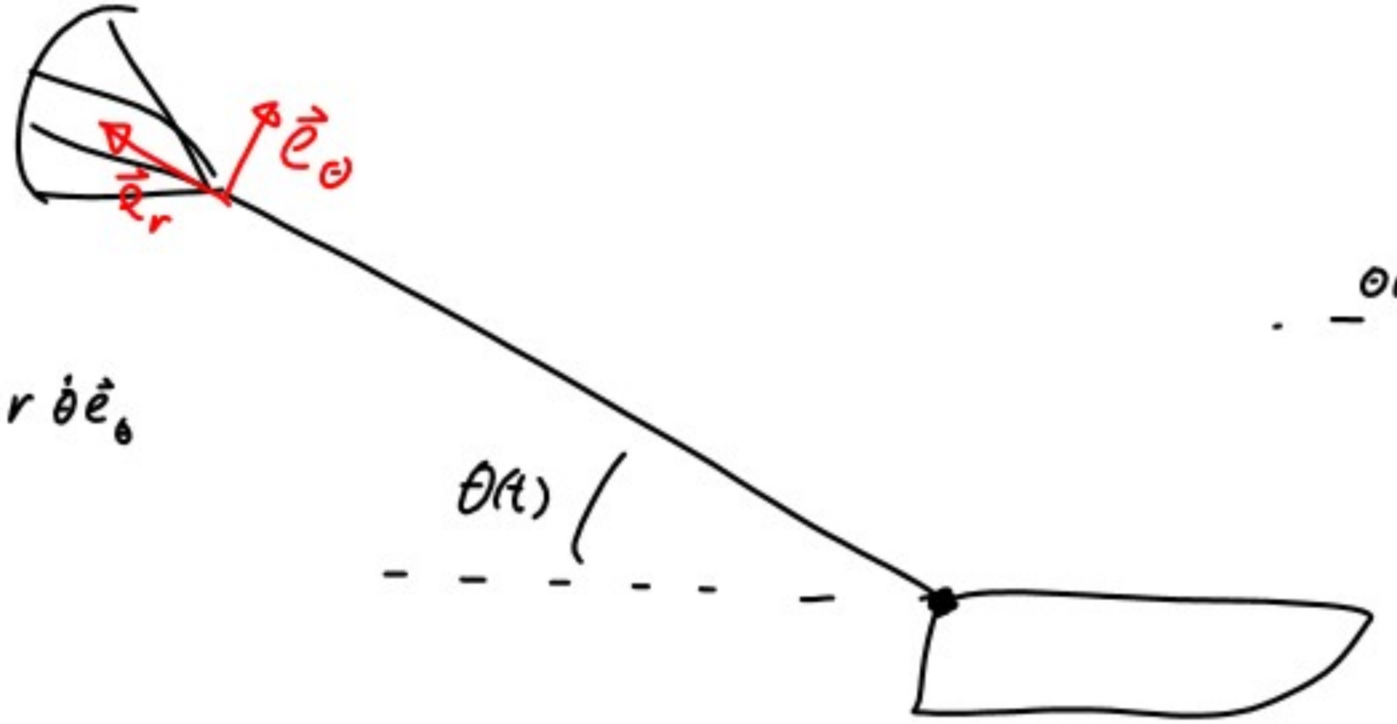
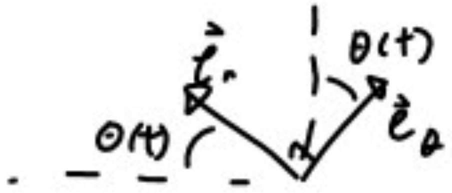
11.164



$$V = \dot{r}\,\vec{e}_r + r\,\dot{\theta}\,\vec{e}_\theta$$



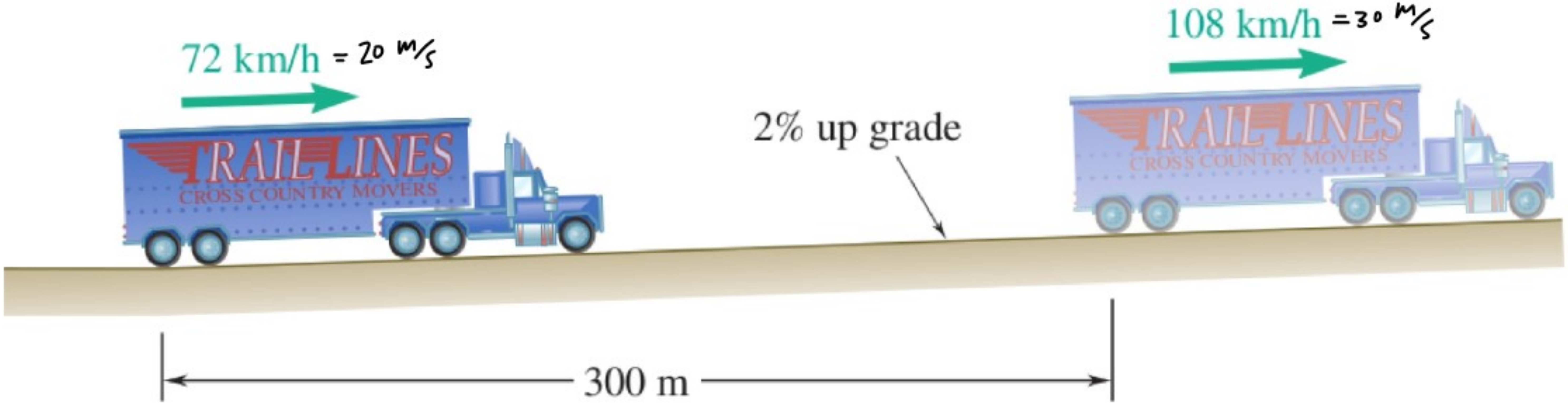
$$\vec{V}_r = \dot{r}\cos\theta(t)\, i + \dot{r}\sin(\theta(t))\, j$$

$$\vec{V}_\theta = r\dot{\theta}\sin\theta(t)\, i + r\dot{\theta}\cos\theta(t)$$

$$\vec{V}_b = V_b\, i$$

$$\vec{V}_t = \vec{V}_r + \vec{V}_\theta + \vec{V}_b$$

13.16 A trailer truck enters a 2 percent uphill grade traveling at 72 km/h and reaches a speed of 108 km/h in 300 m. The cab has a mass of 1800 kg and the trailer 5400 kg. Determine (*a*) the average force at the wheels of the cab, (*b*) the average force in the coupling between the cab and the trailer.

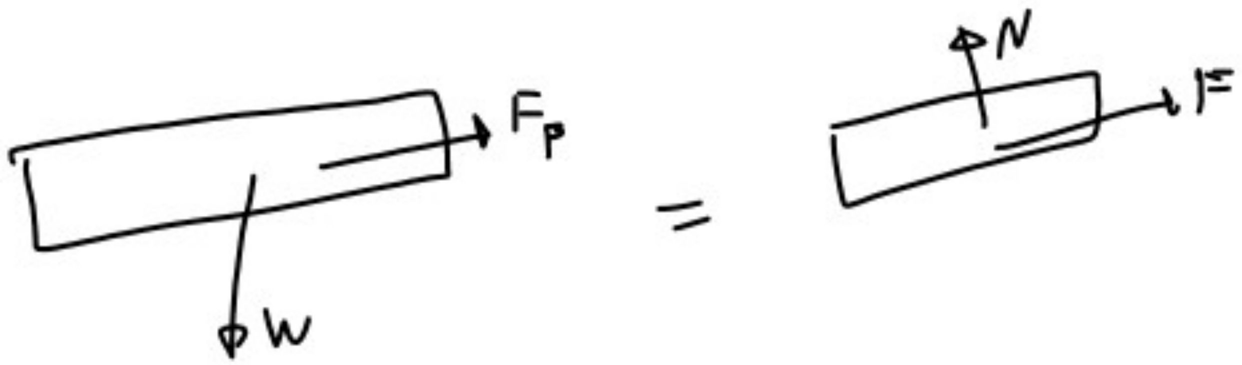


$$\Delta U = W = T_2 - T_1$$

$$T_1 = \frac{1}{2} m V_1^2 = \frac{1}{2} 7200 (20)^2 = 1.44 \times 10^6$$

$$T_2 = \frac{1}{2} m V_2^2 = \frac{1}{2} 7200 (30)^2 = 3.24 \times 10^6$$

$$W = 3.24 \times 10^6 - 1.44 \times 10^6 = 1.8 \times 10^6$$



$$W_F = 0.02\, W_n \qquad \frac{W_F}{0.02} = W_n$$

$$W_F^2 + W_n^2 = W^2$$

$$W_F^2 + \left(\frac{W_F}{0.02}\right)^2 = W^2$$

$$F = F_p - W_F = F_p - \frac{W}{50}$$

$$W_F^2 + \frac{W_F^2}{4 \times 10^{-4}} = W_F^2 + 2500\, W_F^2 = W^2$$

$$W_F^2 (1 + 2500) = W^2$$

$$W_F^2 = \frac{W^2}{1 + 2500} \qquad W_F \simeq \frac{W}{50}$$

$$W = \int F \cdot dr = F d = \left(F_p - \frac{w}{50}\right) 300 = \left(F_p - \frac{7200(9.8)}{50}\right) 300 = 1.8 \times 10^6$$

$$300 F_p - 300 \frac{7200(9.8)}{50} = 1.8 \times 10^6$$

$$300 F_p - 4.23 \times 10^5 = 1.8 \times 10^6$$

$$300 F_p = 1.8 \times 10^6 + 4.23 \times 10^5 = 2.22 \times 10^6$$

$$F_p = \frac{2.22 \times 10^6}{300} = \boxed{7411\ N}$$