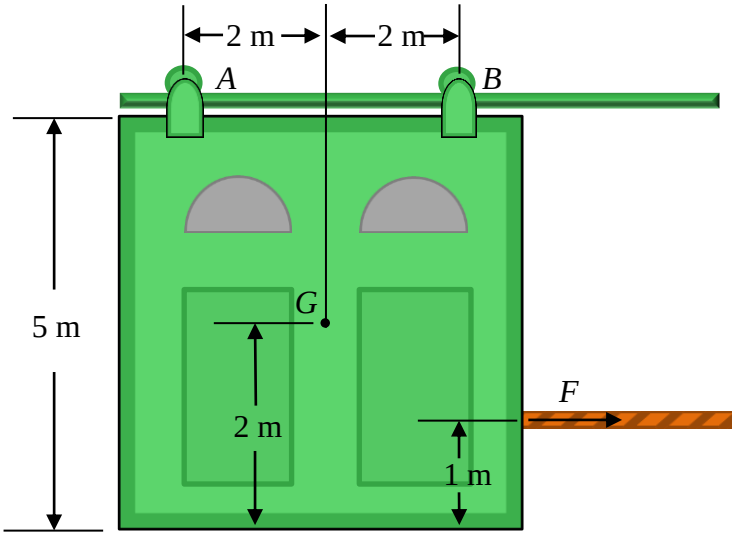
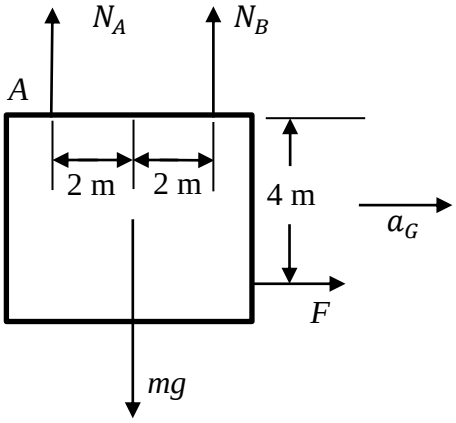
4-6. A company makes garage doors as shown in the figure. The garage door is pulled by a rope with a constant force F that will move the door horizontally a distance s to the right. F is a random variable that follows a normal distribution. The distances of a number of operations are measured in 4 seconds, and this results in a distribution $s \sim N(4, 0.2^2)$ m. The door has a mass of 20 kg and does not touch the ground by hanging from two rollers, A and B. Find the force F and the vertical reaction forces at the rollers.



Solution:



$$s = s_0 + v_0 t + \frac{1}{2} a_G t^2$$

$$a_G = \frac{2s}{t^2}$$

$$\Sigma F_x = m(a_G)_x$$

$$F = \frac{2ms}{t^2}$$

$$\Sigma M_A = N_B(4) - mg(2) + F(4) = m\left(\frac{2s}{t^2}\right)(3)$$

$$N_B = \frac{mg}{2} - \frac{ms}{2t^2}$$

$$\Sigma F_y = N_A + N_B - mg = 0$$

$$N_A = mg - N_B = \frac{mg}{2} + \frac{ms}{2t^2}$$

Thus,

$$\mu_F = \frac{2m}{t^2}\mu_s = 10 \text{ N}$$

$$\sigma_F = \sqrt{\left(\frac{2m}{t^2}\right)^2 \sigma_s{}^2} = 0.5 \text{ N}$$

$$\mu_{N_B} = \frac{mg}{2} - \frac{m}{2t^2}\mu_s = 95.6 \text{ N}$$

$$\sigma_{N_B} = \sqrt{\left(-\frac{m}{2t^2}\right)^2 \sigma_s^2} = 0.13 \text{ N}$$

$$\mu_{N_A} = mg - \mu_{N_B} = 100.6 \text{ N}$$

$$\sigma_{N_A} = \sigma_{N_B} = 0.13 \text{ N}$$

Therefore $F \sim N(10, 0.5^2)$ N; $N_B \sim N(95.6, 0.13^2)$ N; $N_A \sim N(100.6, 0.13^2)$ N. **Ans.**