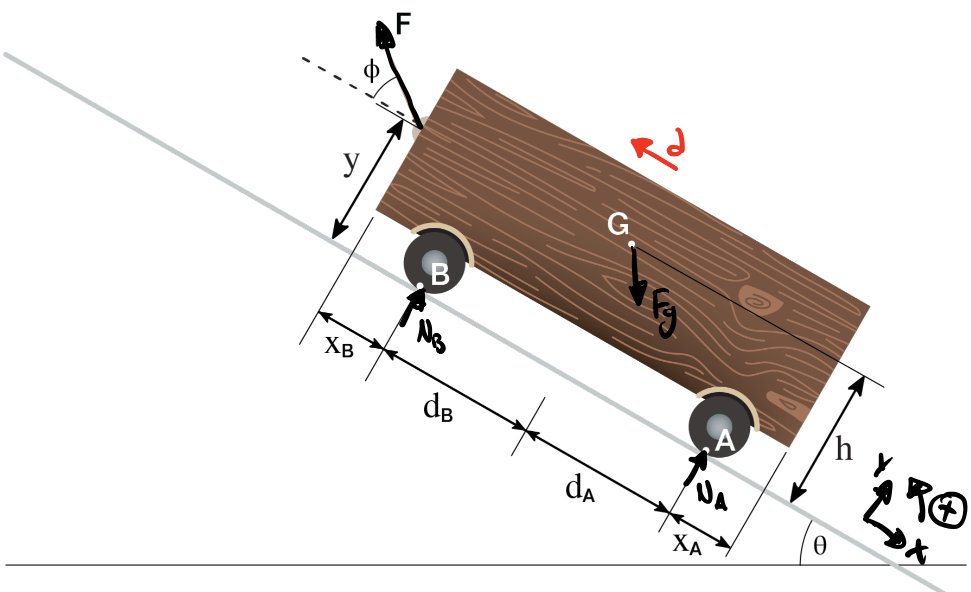
You are hauling a heavy cart up a $\theta = 30\ deg$ incline. Luckily, you have been working out so you can apply a force of $F = 500\ N$ to the cart. If you apply this force at an angle $\phi = 42\ deg$ and the cart has a mass of $m = 30\ kg$, what is the acceleration of the cart and the normal force on each of the cart's wheels? The cart has a center of gravity G. The force is applied at a height y = $0.4\ m$ from the ground and G is located at a height h = $0.5\ m$.

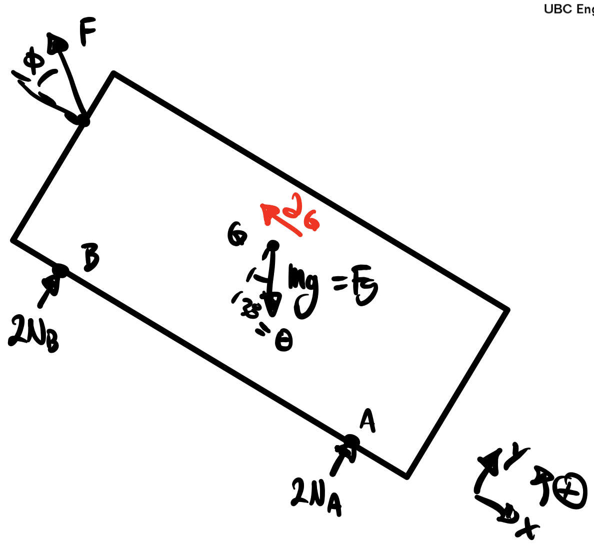
Wheel A is located $x_A = 0.1\ m$ from one side of the cart while wheel B is located $x_B = 0.05\ m$ from the other end.

Wheel A is a distance $d_A = 0.3\ m$ from G while wheel B is a distance $d_B = 0.25\ m$.



① Diagram

FBD



$$\sum F_x = m a_G \Rightarrow -F\cos\phi + F_g \sin\theta = m a_G$$

$$a_G = \frac{-500\text{N}\cos(42^\circ) + (30\text{kg})(9.81\text{ m/s}^2)\sin(30^\circ)}{(30\text{kg})}$$

$$\boxed{a_G = -7.48\text{ m/s}^2}$$

$$\sum F_y = 0 \Rightarrow F\sin\phi - F_g\cos\theta + 2N_B + 2N_A = 0$$

$$\sum M_A = m a_G d \Rightarrow -F_g \sin\theta\, h + F_g \cos\theta\, d_A \ldots$$

$$+ F\cos\phi\, y - F\sin\phi\,(d_A + d_B + x_B)$$

$$- 2N_B(d_A + d_B) = m a_G h$$

$$-(30\text{kg})(9.81\text{ m/s}^2)\sin 30^\circ(0.5\text{m}) + (30\text{kg})(9.81\text{ m/s}^2)\cos 30^\circ(0.3\text{m})$$

$$+ (500\text{N})\cos 42^\circ(0.4\text{m}) - (500\text{N})\sin 42^\circ(0.6\text{m}) - 2N_B(0.55\text{m})$$

$$= (30\text{kg})(-7.48\text{ m/s}^2)(0.5\text{m})$$

$$\boxed{N_B = 57.26\text{N} \qquad N_A = 97.11\text{N}}$$