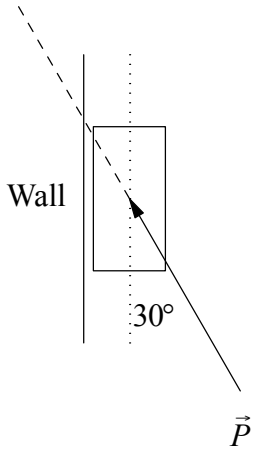
2. (30 pts.) A student pushes a 4 kg book up a vertical wall by applying a force $\vec{P}$ at an angle of 30° from the vertical, as shown in the figure. The student pushes the book up the wall a distance of 0.4 m at a constant speed of 0.17 m/s. The coefficient of kinetic friction between the book and the wall is 0.3.

a. (20 pts.) How much work is done by the student?



b. (10 pts.) What is the total work done by all forces on the box? *Hint*: Think carefully. It is possible to answer this without any calculations, but you must carefully justify your answer.

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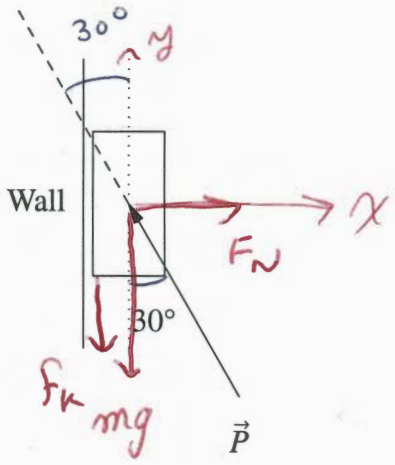

$W = Pd\cos 30°$, $d = 0.4\,m$. $P = ?$

$\Sigma \vec{F} = m\vec{a}$

$\Sigma F_x = ma_x$

$-P\sin\theta + F_N = 0 \Rightarrow F_N = P\sin\theta$

$\Sigma F_y = ma_y$

$P\cos\theta - mg - f_k = 0$

$P\cos\theta - mg - \mu_K P\sin\theta = 0$

$$P = \frac{mg}{\cos\theta - \mu_K \sin\theta}$$

$$P = \frac{(4)(9.8)}{\cos 30° - 0.3\sin 30°} = 54.75\,N$$

$W = Pd\cos 30° = (54.75)(0.4)\cos 30°$

$\boxed{W = 18.96\,J}$

b. (10 pts.) What is the total work done by all forces on the box? *Hint*: Think carefully. It is possible to answer this without any calculations, but you must carefully justify your answer.

$K_i + W_{total} = K_f$. Since $v = \text{constant} = 0.17\,m/s$,

$K_i = K_f$, $\boxed{W_{total} = 0.}$

Thinking from an energy perspective:

$$K_i + U_i + W_{other} = K_f + U_f$$

$$K_i + mgy_i - f_k \Delta y + P\cos 30^\circ \Delta y = K_f + mgy_f$$

bring this to the left

$$K_i + mg(y_i - y_f) - f_k \Delta y + P\cos 30^\circ \Delta y = K_f$$

this is $-\Delta y$

$$K_i \underbrace{- mg\Delta y - f_k \Delta y + P\cos 30^\circ \Delta y} = K_f$$

These 3 are the total work done by <u>all</u> forces, including gravity.

$$K_i + W_{total} = K_f$$

In this problem, $K_i = K_f$, so <u>$W_{total} = 0$</u>