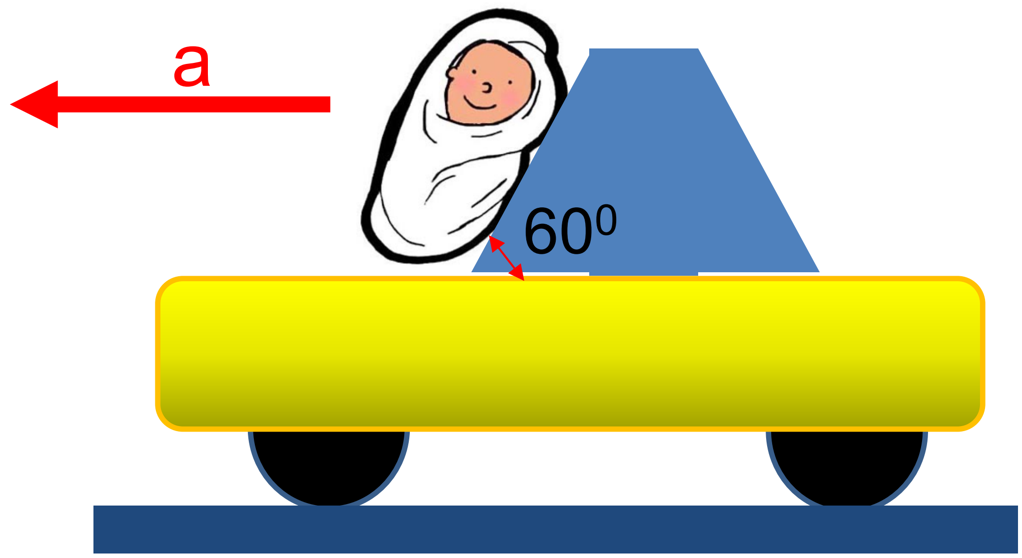
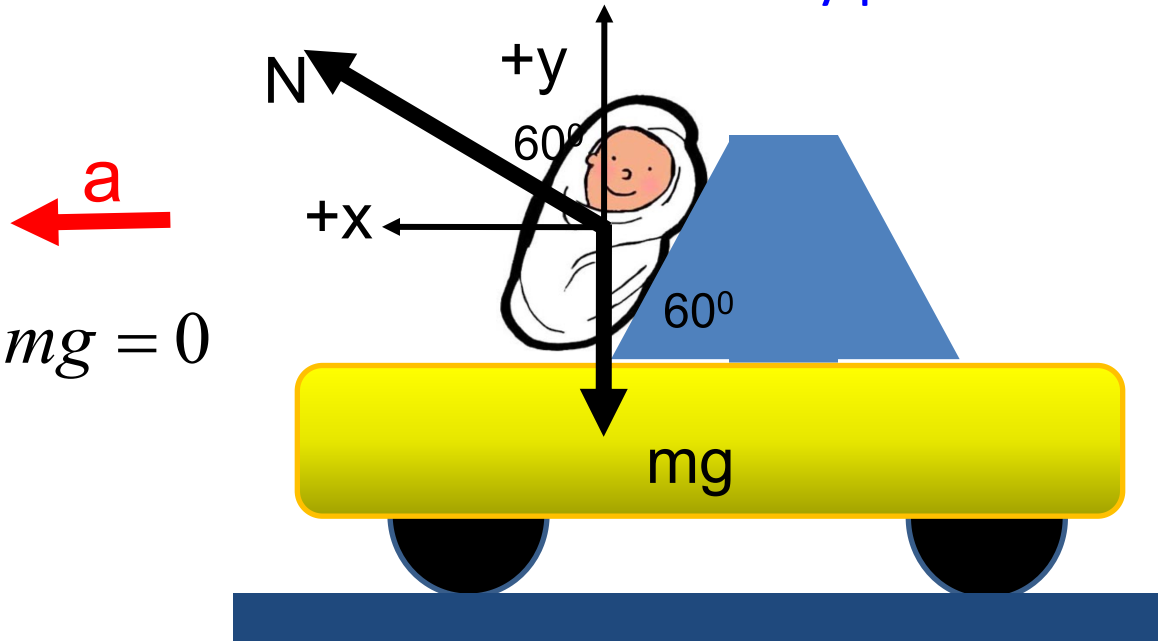
A baby falls from a tree onto the front windshield of Mary's car just as she drives underneath. The windshield is inclined at 60^0 with respect to horizontal, as shown below. Mary is horrified, realizing that the baby could fall to the ground with disastrous consequences. She steps on the gas and her car begins to accelerate, holding the baby on the windshield. What is the ***minimum*** acceleration required? Of course, this is just a temporary solution. By the way, the window may be frictionless!



Mary's solution. We have to assume that the window has no friction. This looks like a setup for a tilted coordinate system, but the acceleration is horizontal. So, lets use a coordinate system with x parallel to the acceleration. This works for almost every problem.



$$\sum F_y = 0 = N\cos\theta - mg = 0$$

$$N\cos\theta = mg$$

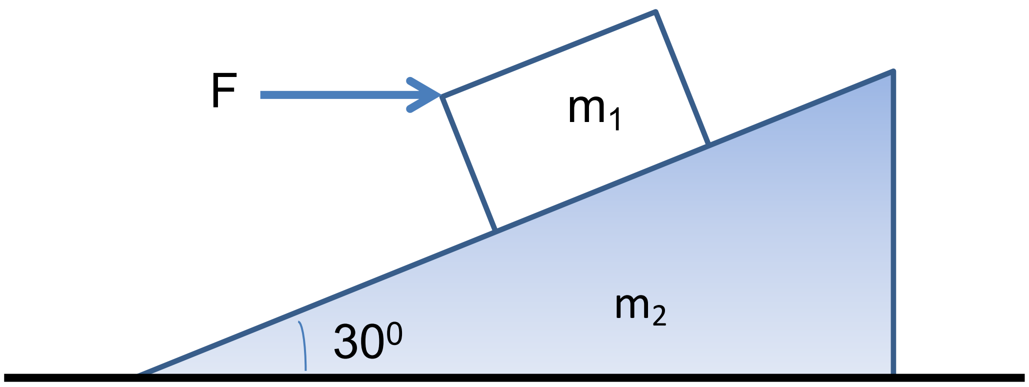
$$N\sin\theta = ma$$

$$\tan\theta = \frac{a}{g}$$

$$a = g\tan\theta = g\tan 60^0 = 1.7g$$

Example

The two blocks with m_1 = 1 kg and m_2 = 4 kg with no friction between them. Also, the floor is frictionless. What is the F so that m_1 doesn't slid?



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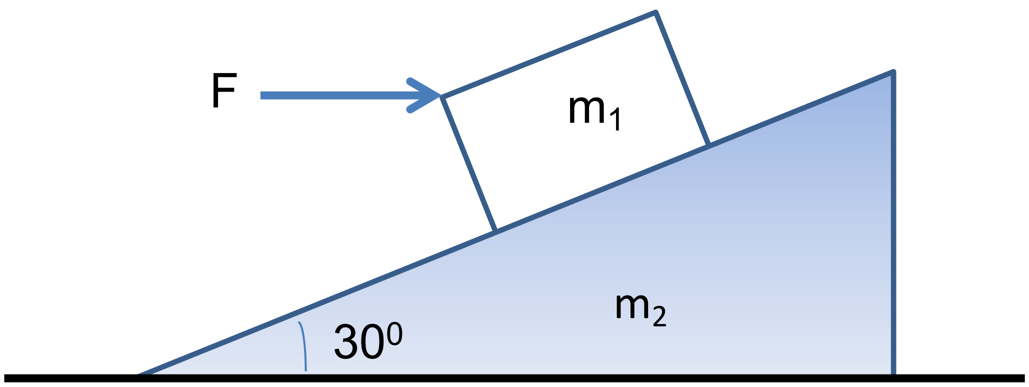

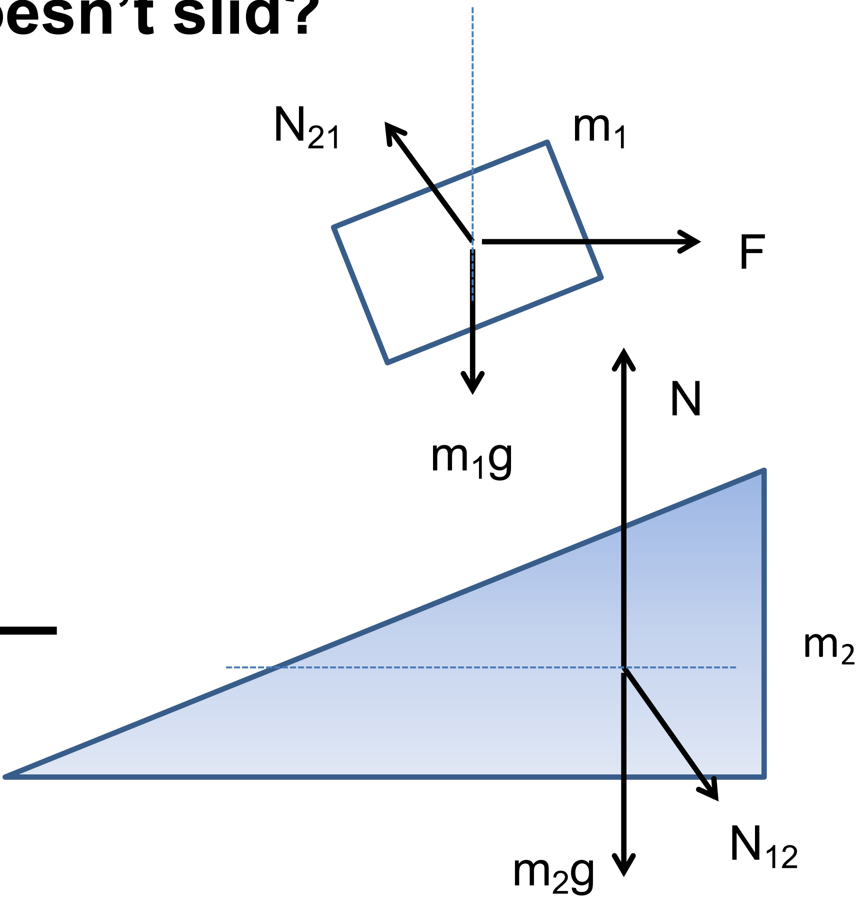

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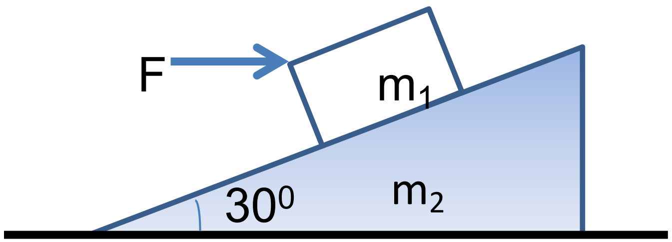
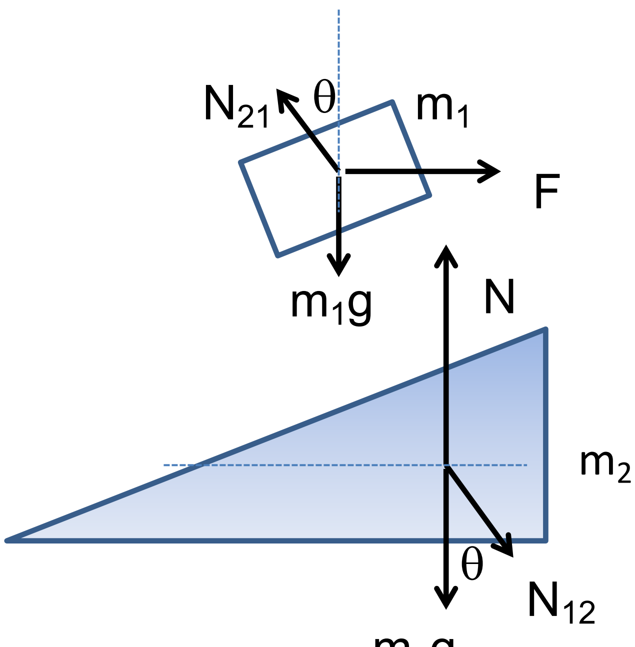


$N_{21}\cos\theta = m_1 g$ $N_{21} = m_1 g/\cos\theta$



$F - N_{21}\sin\theta = m_1 a$

$N_{12}\sin\theta = m_2 a$ $(N_{12} = N_{21})$

$F = N_{21}\sin\theta + N_{12}\sin\theta\, m_1/m_2$

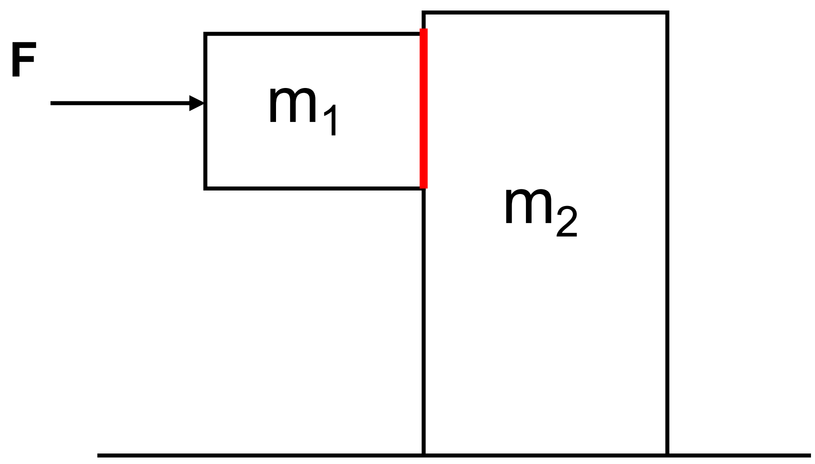
$$F = N_{21}\sin\theta\left(1 + \frac{m_1}{m_2}\right) = m_1 g\,\frac{\sin\theta}{\cos\theta}\left(1 + \frac{m_1}{m_2}\right)$$

$$= m_1 g\tan\theta\left(1 + \frac{m_1}{m_2}\right) = 7.1\ \text{N}$$

Example

The two blocks with m_1 = 16 kg and m_2 = 88 kg are not attached. Between them we have μ_s = 0.38. The floor is frictionless.

What is the minimum F so that m_1 doesn't fall?



(F_{min}=487.7 N)

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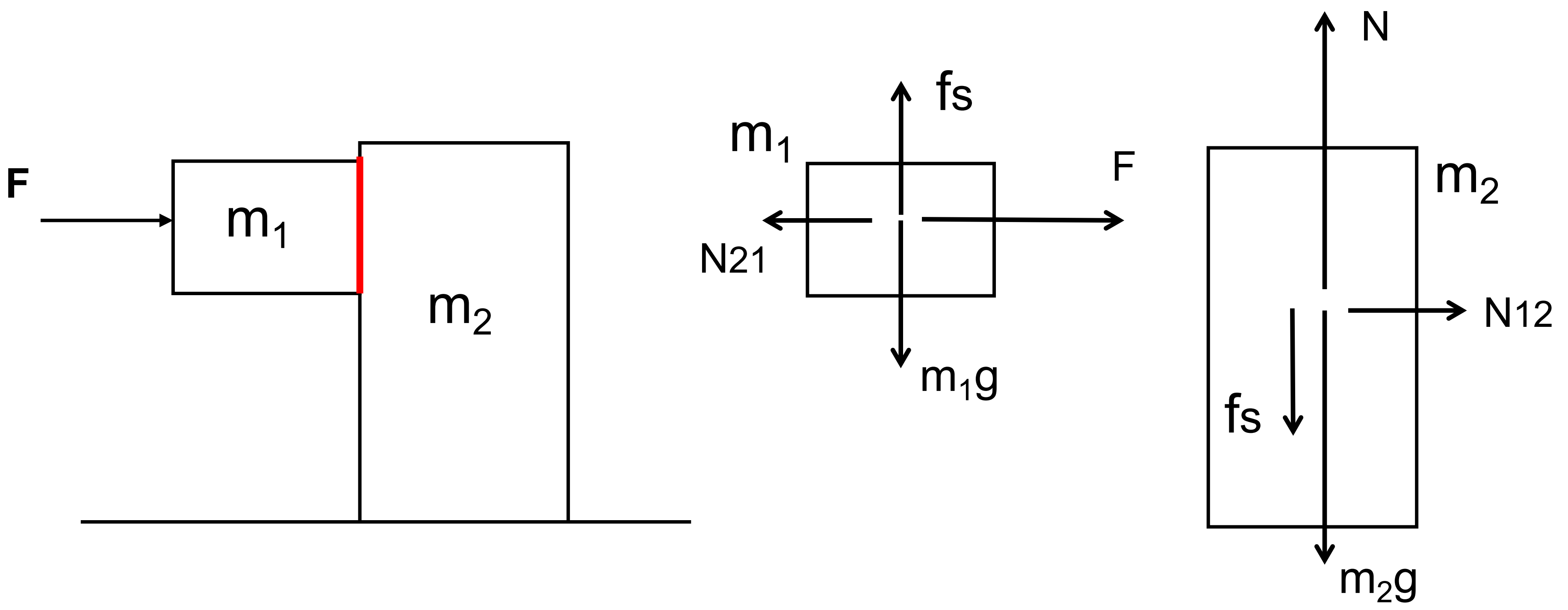

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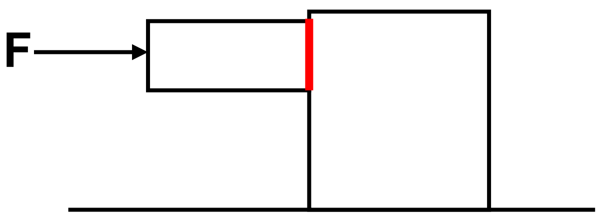

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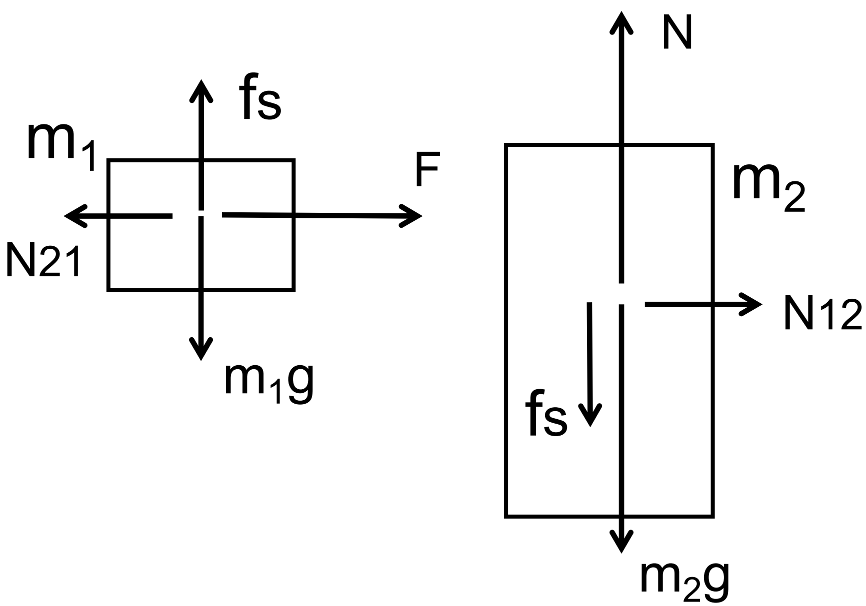

$F - N_{21} = m_1 a$

$N_{12} = m_2 a \qquad a = N_{12}/m_2$

$F = N_{21} + (m_1/m_2) N_{12}$

$= \left(1 + \frac{m_1}{m_2}\right) N_{21}$

fs$= m_1 g \leq usN_{21}$

$N_{21} \geq \frac{m_1 g}{u_s}$

$F \geq \left(1 + \frac{m_1}{m_2}\right)\frac{m_1 g}{u_s}$ =487.7 N