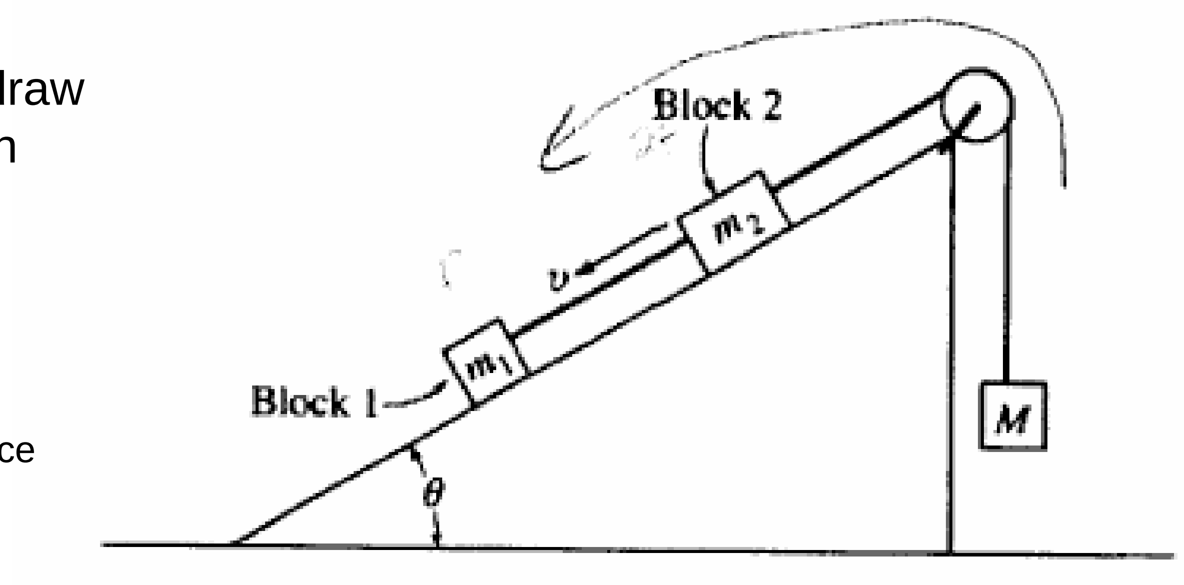
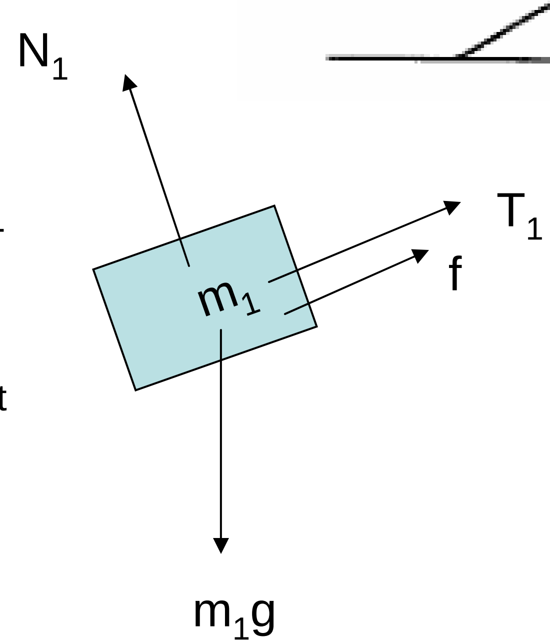
a. On the figure below, draw and label all the forces on block m_1.



This is normal force

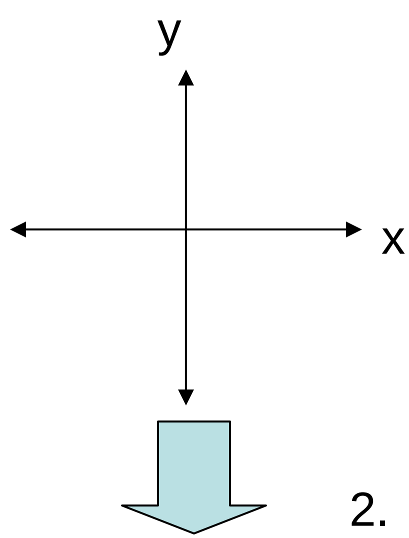


Note: Since block 1 moves down the incline at constant velocity, it is NOT accelerating (no net force on mass 1)

Note that tension and friction are hindering mass 1 from accelerating down the incline.

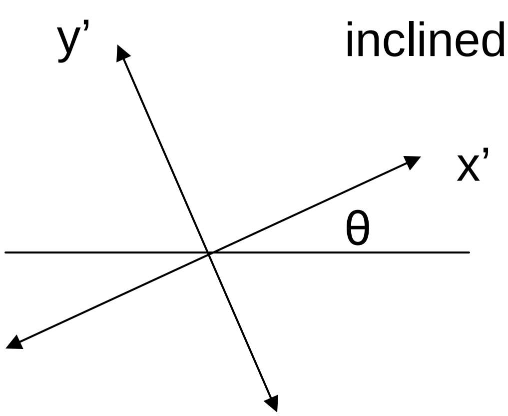
Gravity acts on all masses, straight down

You should understand that whenever you're dealing with forces along an incline, it is convention to choose a convenient set of axes.

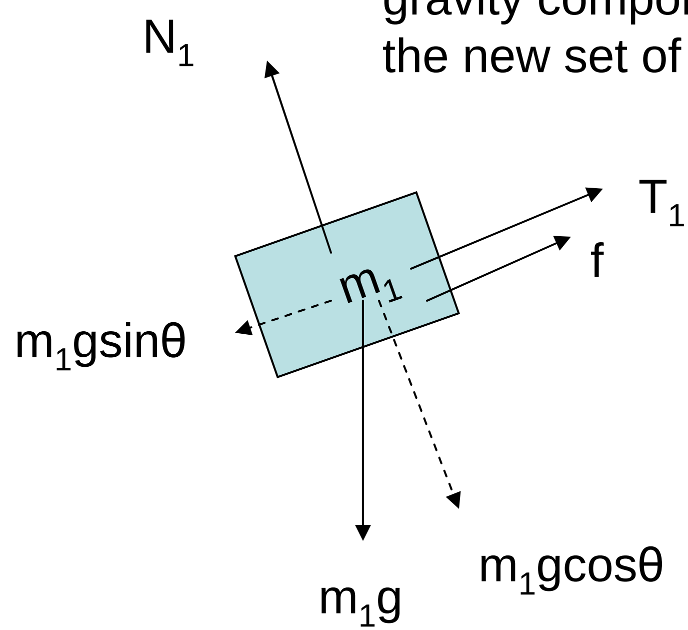


1. This is what we normally use, in "straight" situations

2. This is more convenient for inclined planes



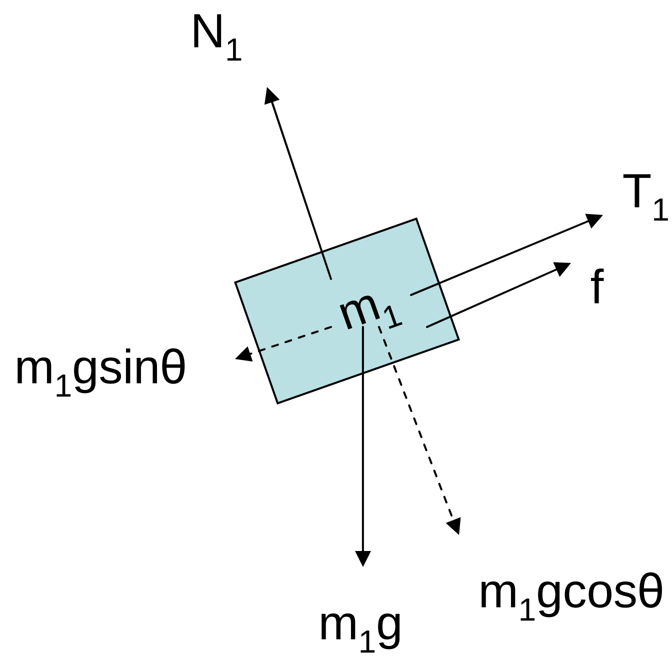
3. That's why we split the gravity component along the new set of axes



b. Determine the coefficient of kinetic friction between the inclined plane and block 1.

$$\sum F_{y'} = 0 = N_1 - m_1 g \cos q$$

Blocks don’t accelerate above the incline.



$$\sum F_{x'} = m_1 a = m_1 g \sin q - (T_1 + f)$$

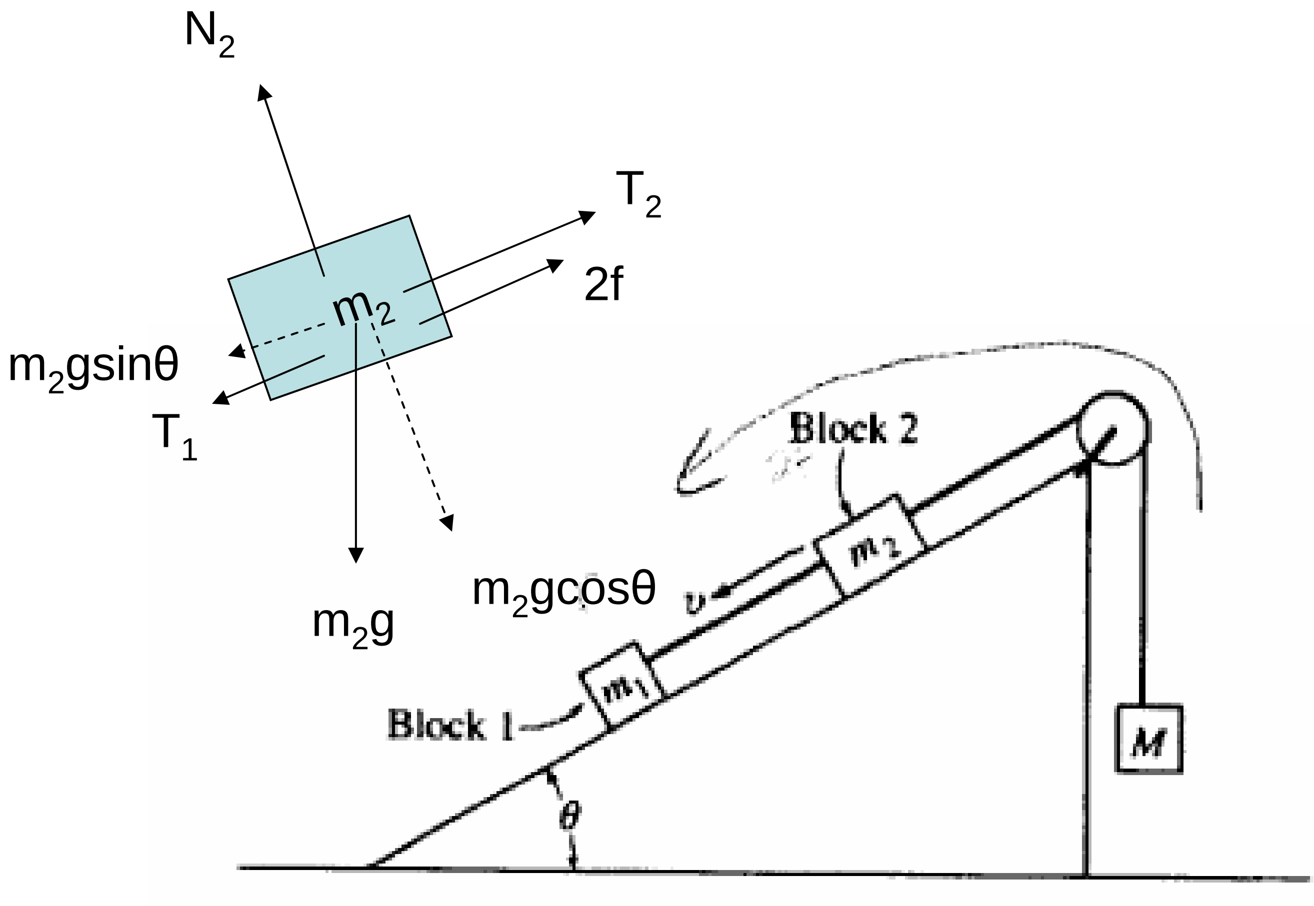
Note that in this case, mass 1 is NOT accelerating, so let’s rewrite.

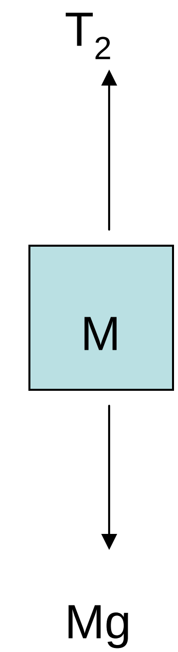
$$\sum F_{x'} = 0 = m_1 g \sin q - (T_1 + f)$$

$$f = m_1 g \sin q - T_1$$

So we really need to figure out what T is before moving forward. We’ll need to pay attention to the rest of the set-up.

So here are the other two free-body diagrams:





$$\sum F = 0 = T_2 - Mg$$
$$T_2 = Mg$$

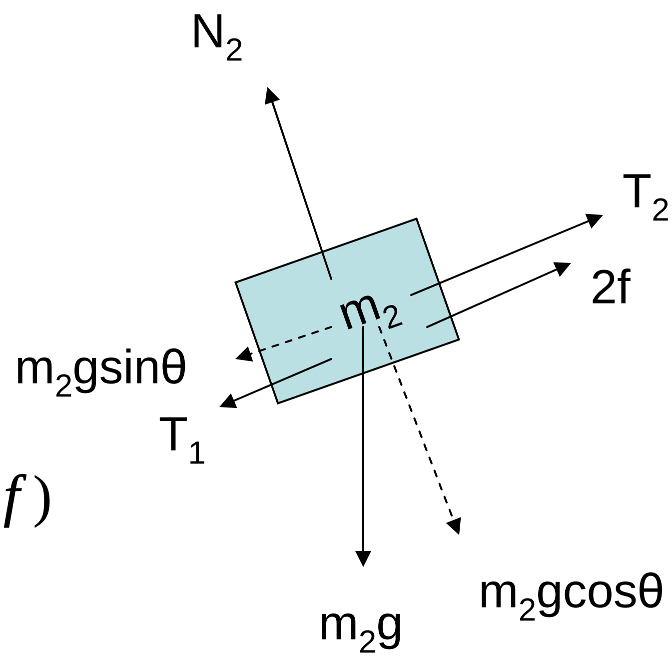
Immediately, from mass M (on right), we can say that T_2 is equal to Mg, because remember, this entire system is NOT accelerating.

Let's deal with Newton's law on mass 2, and try to solve for T_1:

(If it wasn't clear before, you can't assume that both tensions T_1 and T_2 are the same, even though sometimes, they are.)

$$\sum F_{y'} = 0 = N_2 - m_2 g \cos q$$

Blocks don't accelerate above the incline.



$$\sum F_{x'} = m_2 a = (m_2 g \sin q + T_1) - (T_2 + 2f)$$

$$\sum F_{x'} = 0 = (m_2 g \sin q + T_1) - (T_2 + 2f)$$

Note that in this case again, mass 2 is NOT accelerating.
Also remember now that T_2 = Mg (from last slide).

$$\sum F_{x'} = 0 = (m_2 g \sin q + T_1) - (Mg + 2f)$$

$$T_1 = Mg + 2f - m_2 g \sin q$$

Yes! Now we figured out T_1!

OK Now. Let's put together the important things we've found out so far.

From mass 1:

$$\sum F_{y'} = 0 = N_1 - m_1 g \cos q$$

$$\sum F_{x'} = 0 = m_1 g \sin q - (T_1 + f)$$

$$f = m_1 g \sin q - T_1$$

From mass 2:

$$\sum F_{x'} = 0 = (m_2 g \sin q + T_1) - (Mg + 2f)$$

$$T_1 = Mg + 2f - m_2 g \sin q$$

So plug in T_1 and solve for f:

$$f = m_1 g \sin q - (Mg + 2f - m_2 g \sin q)$$

$$3f = m_1 g \sin q - Mg + m_2 g \sin q$$

$$f = \frac{m_1 g \sin q - Mg + m_2 g \sin q}{3}$$

So one last thing.. we've solved for the frictional force, but not the coefficient of friction.

As a reminder, here's the equation for frictional force:

$$f = mN$$

Let's use the normal force N_1 from mass 1, and solve for μ.

$$f = mN_1 = \frac{m_1 g \sin q - Mg + m_2 g \sin q}{3}$$

$$\sum F_{y'} = 0 = N_1 - m_1 g \cos q$$

$$N_1 = m_1 g \cos q \longrightarrow m = \frac{m_1 g \sin q - Mg + m_2 g \sin q}{3N_1}$$

$$m = \frac{m_1 g \sin q - Mg + m_2 g \sin q}{3 m_1 g \cos q}$$

I hope this helps!