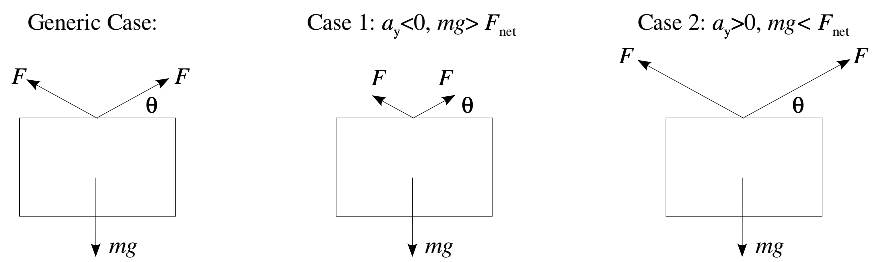
Physics 10310,
Discussion Section Solutions

Set 4

1. The point is that the net force on the block from the strings comes from the vertical component, and that the total force is equal to the mass times the acceleration. Choose the positive y direction to be up. Then,

$$F_{net} = 2F_y = 2F\sin\theta, \quad \sum F_y = ma_y = F_{net} - mg$$

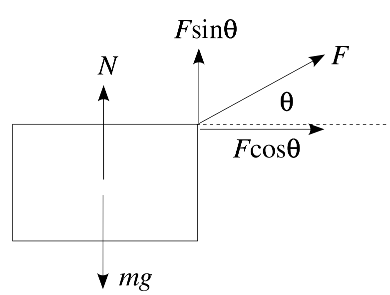
For the four cases, the only thing that matters is what direction the acceleration has. So, in Case 1, the block accelerates downward, $a_y < 0$, which implies $mg > F_{net}$. In Case 2, the block accelerates upward, so $a_y > 0$, which implies $mg < F_{net}$. Case 3 is the same as Case 2, and Case 4 is the same as Case 1. Note that the instantaneous velocity has *NO* relation to the acceleration; the acceleration is the *change* in velocity ($\vec{a} = \Delta\vec{v}/\Delta t$). So, in the diagram below, the arrows have been drawn to reflect the relative size of mg and F_{net}. Note that mg is always the same if we use a constant scale.



2. a) The figure below shows the forces acting on the block, and has the force F broken down into components. If the vertical component of the force F exceeds the blocks weight, then there will be a vertical acceleration and the block will move up. Otherwise, the sum of the normal force $\mathcal{N}$ and $F\sin\theta$ will exactly balance the weight. So, the smallest the normal force can be is zero, in which case we have:

$$\sum F_y = 0 = F\sin\theta - mg, \quad F = mg/\sin\theta.$$

So, for $F > mg/\sin\theta$ the block will lift up.



b.) $\sum F_x = ma_x = F\cos\theta$, $a_x = F/m\cos\theta$. $a_y = 0$.

c.) To find D, we need to know the velocity with which the block leaves the platform after accelerating; this will be the initial velocity for the projectile motion. The easiest way to do this is

$$v_f^2 = v_0^2 + 2a\Delta x; \quad v_0 = 0,\ \Delta x = L \Rightarrow v_f^2 = 2F/mL\cos\theta; \quad v_f = \sqrt{\frac{2FL}{m}\cos\theta}$$

For the projectile, the v_f we just found is v_{0x}, and $v_{0y} = 0$. Now, since $D = v_{0x}t$ we only need the time it takes to fall. We can find this by looking at the equation for the vertical position:

$$y = H - \frac{1}{2}gt^2 = 0; \qquad t = \sqrt{\frac{2H}{g}}$$

where t is the time of impact at the bottom. So, putting this into

$$D = v_{0x}t = \sqrt{\frac{2FL}{m}\cos\theta}\sqrt{\frac{2H}{g}} = 2\sqrt{\frac{FLH}{mg}\cos\theta}.$$

And, just to check, it even has units of distance...