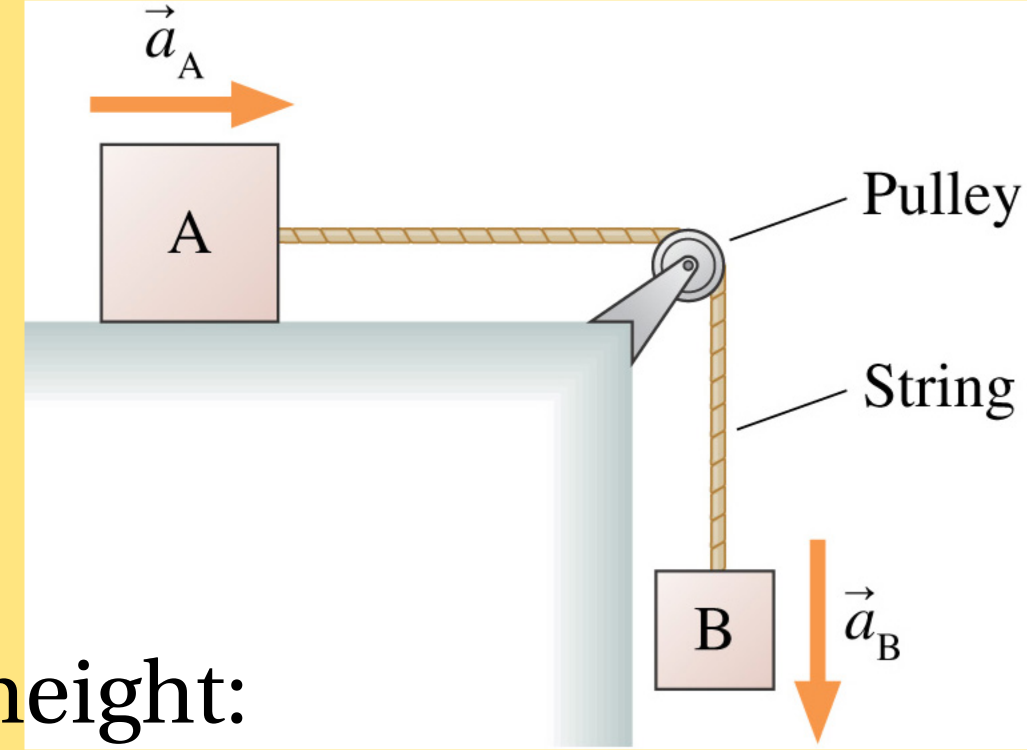
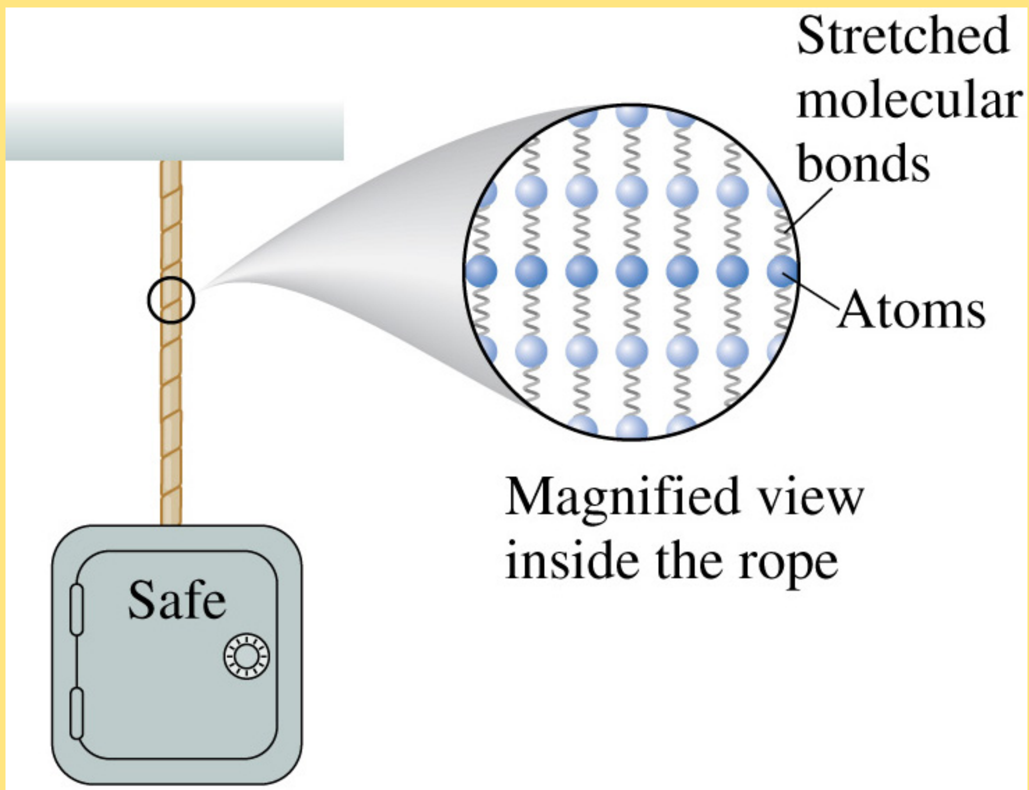
Ropes and Pulleys



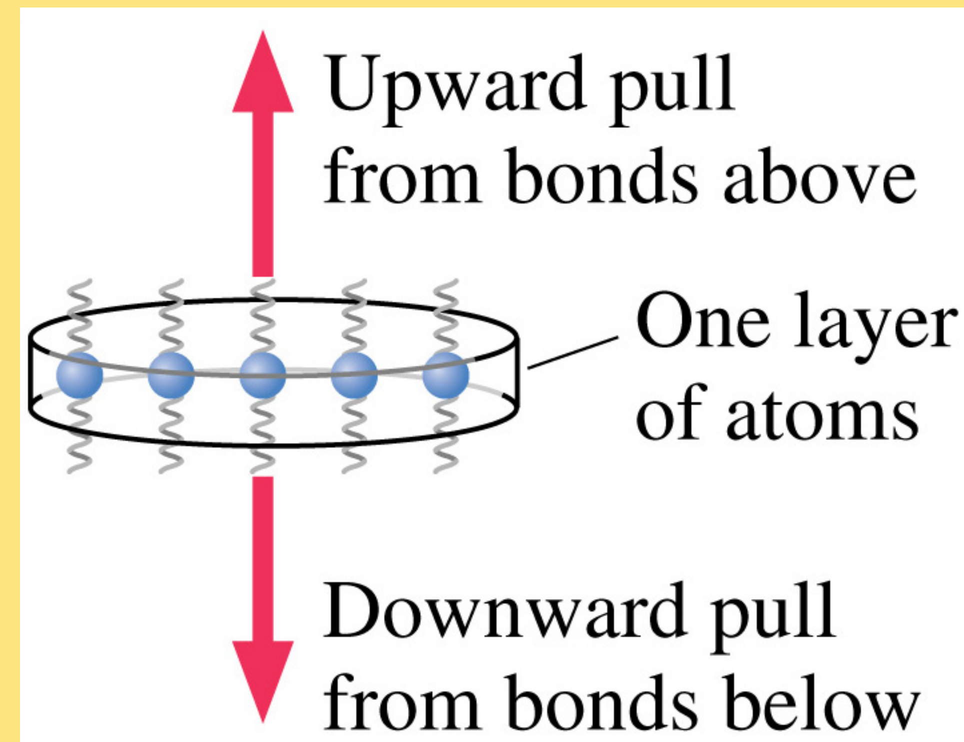
Non-stretching string and pulley:
re-direct acceleration vectors

To understand strings (ropes):
re-visit tension force



Cut rope at any height:
mass falls! ⇒
tension is
everywhere!

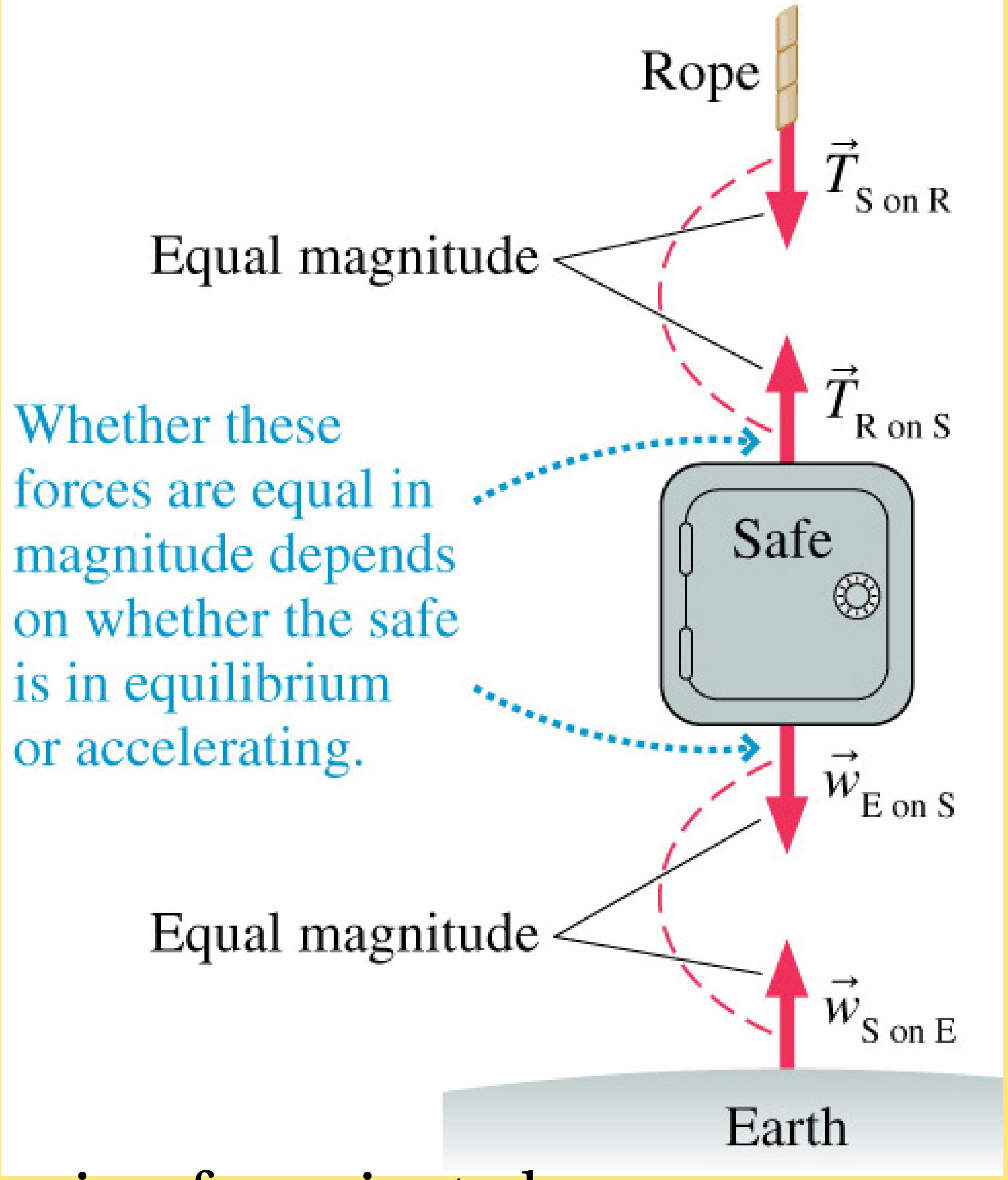
∞-ly many
free-body
diagrams?



No, assume the string to be massless
Rope transmits the same tension force from one end to the other
Not meaningful to apply Newton's 2nd to a layer of $m = 0$ atoms

Bond springs are ultra-stiff (huge k) ⇒ tiny displacement

Moving Ropes



Suppose a crane can lower/heighten the load attached to the rope.

What is the tension force if the mass is accelerated upward by $\vec{a}$?

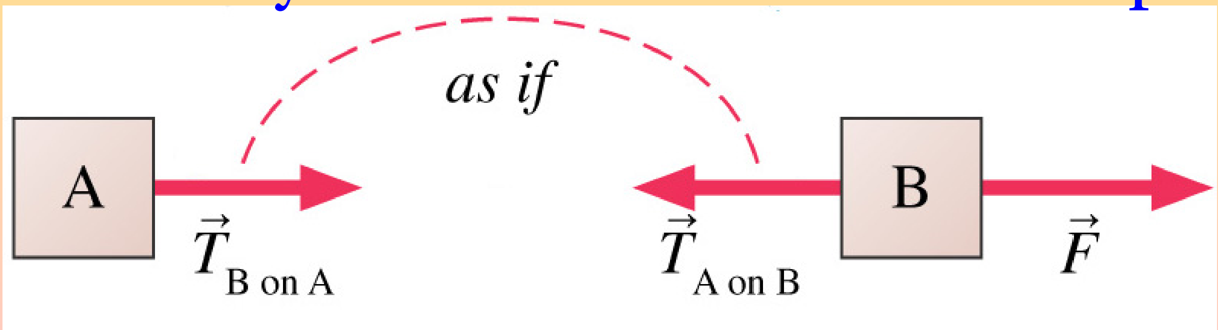
$|\vec{w}_{\text{E on S}}| = |\vec{T}_{\text{R on S}}|$ only holds when S is at rest, or moves with constant velocity

Newton's 2$^{\text{nd}}$:

If $a_S \neq 0$, then from $m_S \vec{a}_S = \vec{F}_{S,\text{net}}$ it follows that $\vec{F}_{S,\text{net}} = \vec{T}_{\text{R on S}} + \vec{w}_{\text{E on S}}$

Moral: suppose a rope is rated for a maximum tension force just above $m_S g$.
What happens when the crane (towing car) accelerates like mad ?
What if the car to be towed left the emergency brake on ?

Important short-cut for massless strings: treat tension forces at ends as if they were an action-reaction pair, and ignore the string.



This also works when the string bends around by moving over a pulley, at least in the massless pulley approximation