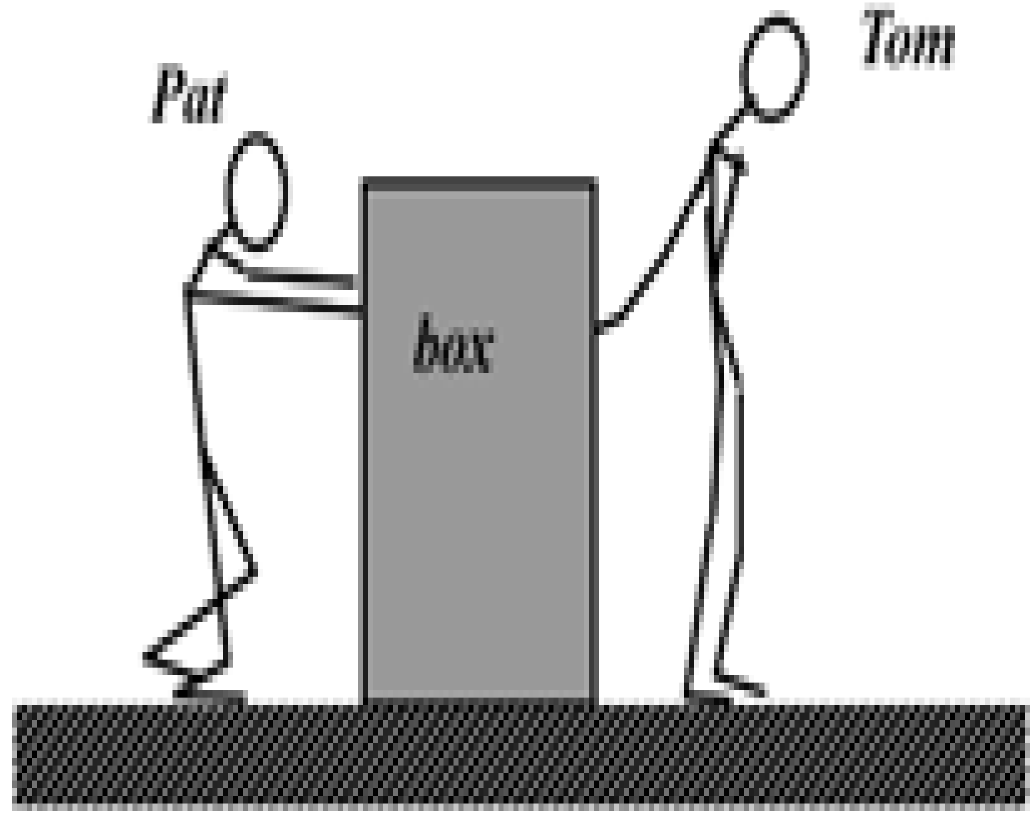
Friction & Tension

Question 1. Pulling and Pushing a box on a rough surface at constant speed

Tom is pulling a box along a horizontal and rough surface by applying a force at an angle of 45º with respect to the horizontal. Pat is helping him by pushing the box with a force parallel to the horizontal as shown.



Strategic Questions to ask yourself

- What is the acceleration of interest?
- Which ***physics principle*** immediately comes to mind if you know the acceleration?
- How many independent systems are involved in this situation?
- What interactions can you identify in each system?
- Why draw FBDs of all of them?

What are the INTERACTIONS?

ON what? BY what?

NIII: (Thing 1 **ON** thing 2) =
(Thing2 **back ON** Thing 1)

Simplify your notation:

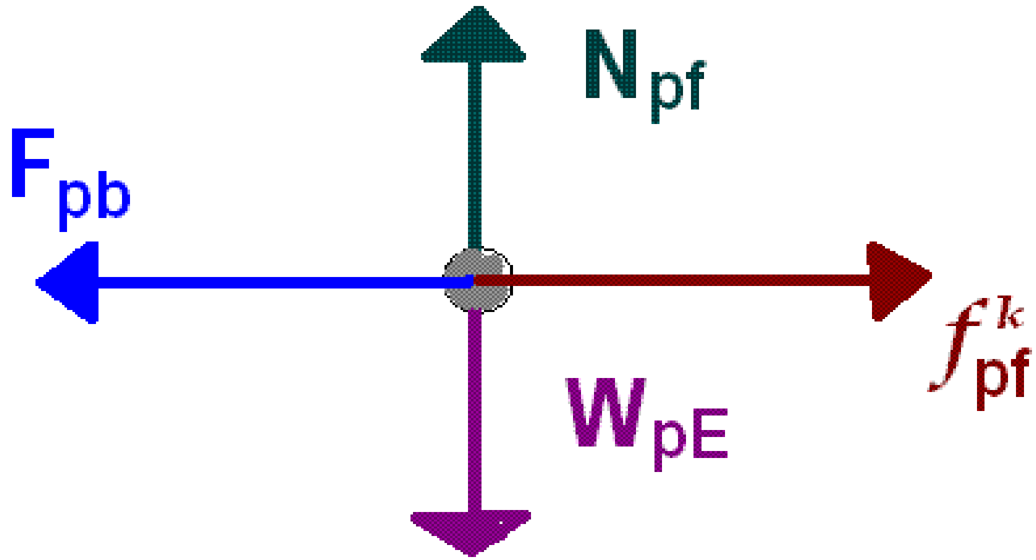
N = normal or supporting forces

W= mg= local gravitational weight

T = tension forces in direction of ropes/strings

Draw FBD of Pat

p= Pat
b= box
f= floor
E= Earth



f^{k}: *kinetic friction*

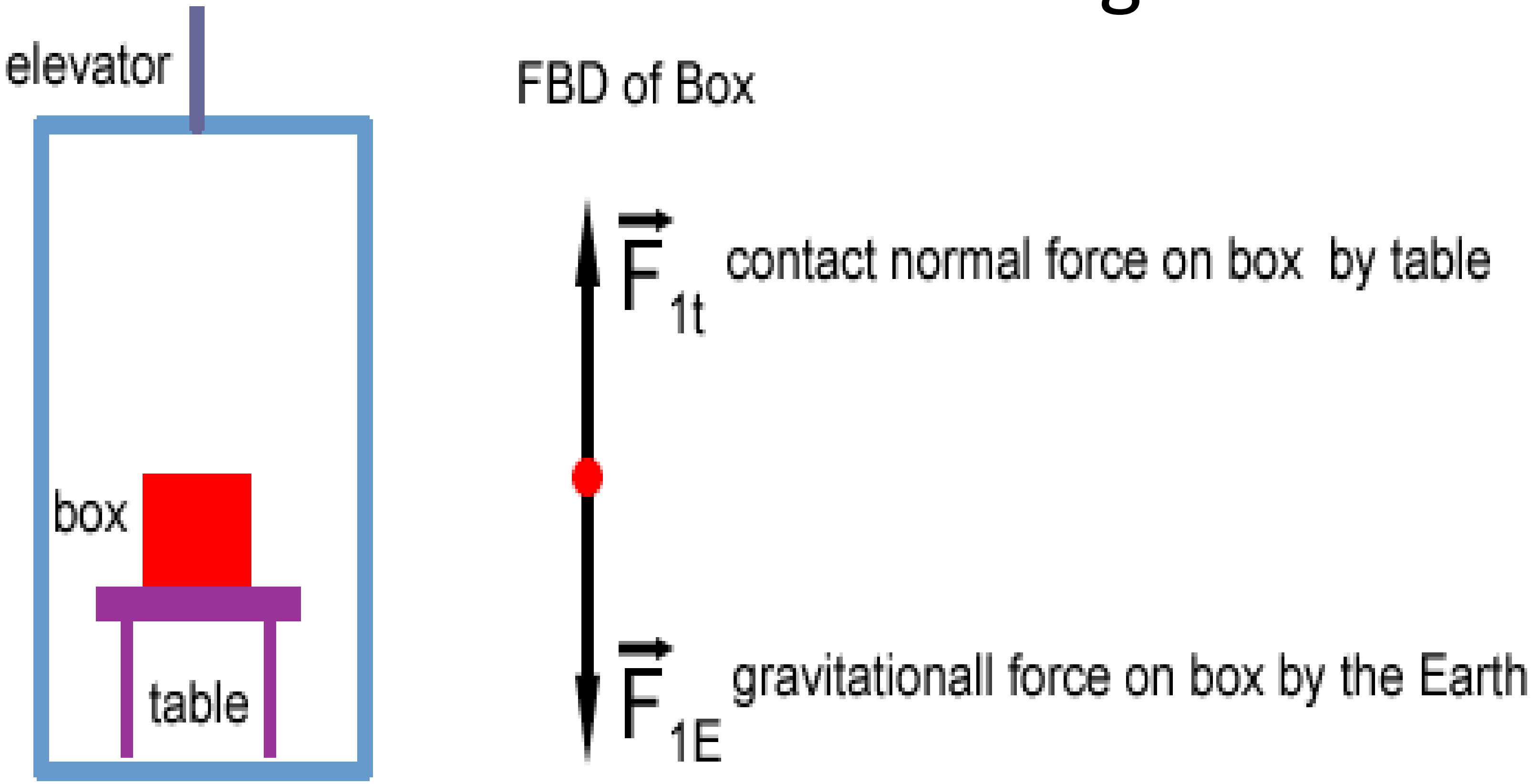
Normal forces

- Contact forces that prevent boundary intrusion
- Normal = **Perpendicular** to surface boundary
- What determines the **magnitude** of Normal forces?
- **Constraint:** in order to remain in contact, both surfaces must move together or have the same component of velocity perpendicular to the contact surface.

Normal force constraint

- Real surface interaction example.
- Hold the hoop horizontal, have a partner put a mass on the latex surface.
- Consider three moments in time: t1 at first contact, t2 before the mass has stopped moving, t3 when the mass is in equil with the latex surface DRAW THREE FBDs… and compare

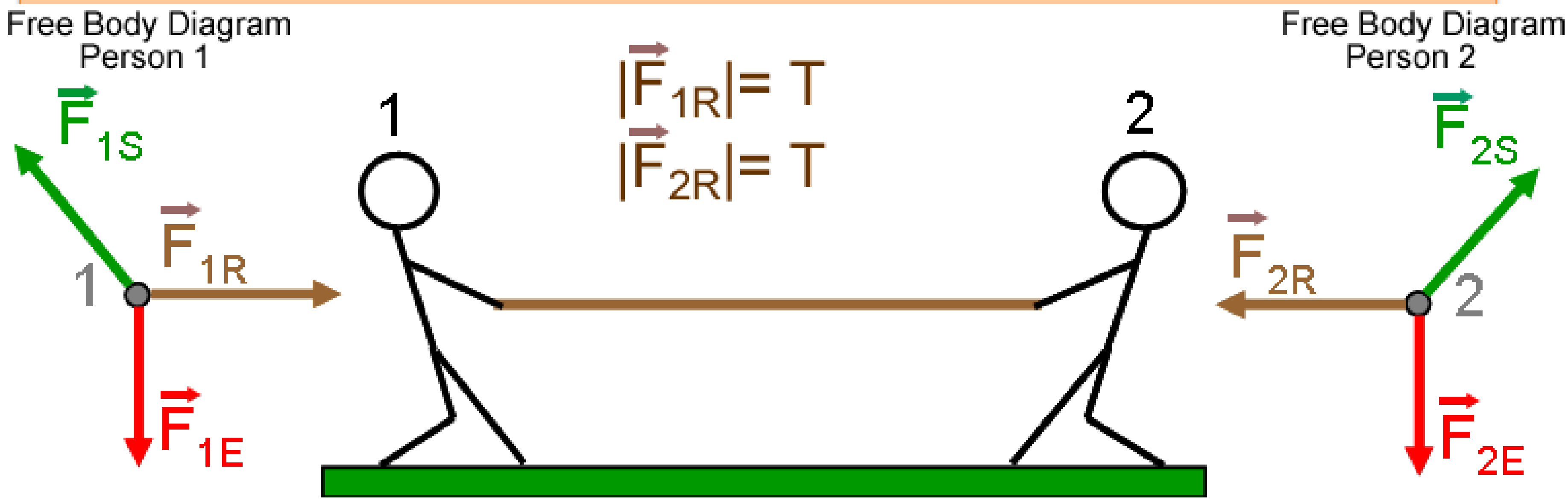
Normal forces vary.. How big is the normal force on this box in the moving elevator?



$\mathbf{F}_{1t} = \mathbf{N}_{1t}$ DEPENDS on the motion (acceleration) of the box, therefore it varies….. In order to know $\mathbf{N}_{1t}$

we have to apply **NII** $\sum \mathbf{F}_1 = ma$

Tension... and then friction



- S means Surface. What distinct interactions give rise to the force on each person due to the surface?
- What would happen to person 1 if the friction by the surface on 1 went to zero?
- What would happen to person 1 if the rope suddenly went slack?

Tension is the same at both ends of any segment of a rope being pulled at both ends (“under tension”)

- **Tension** acts along the ***direction*** of the rope.
- If the rope is shorter, but the pull on the ends is the same? Does the tension change?

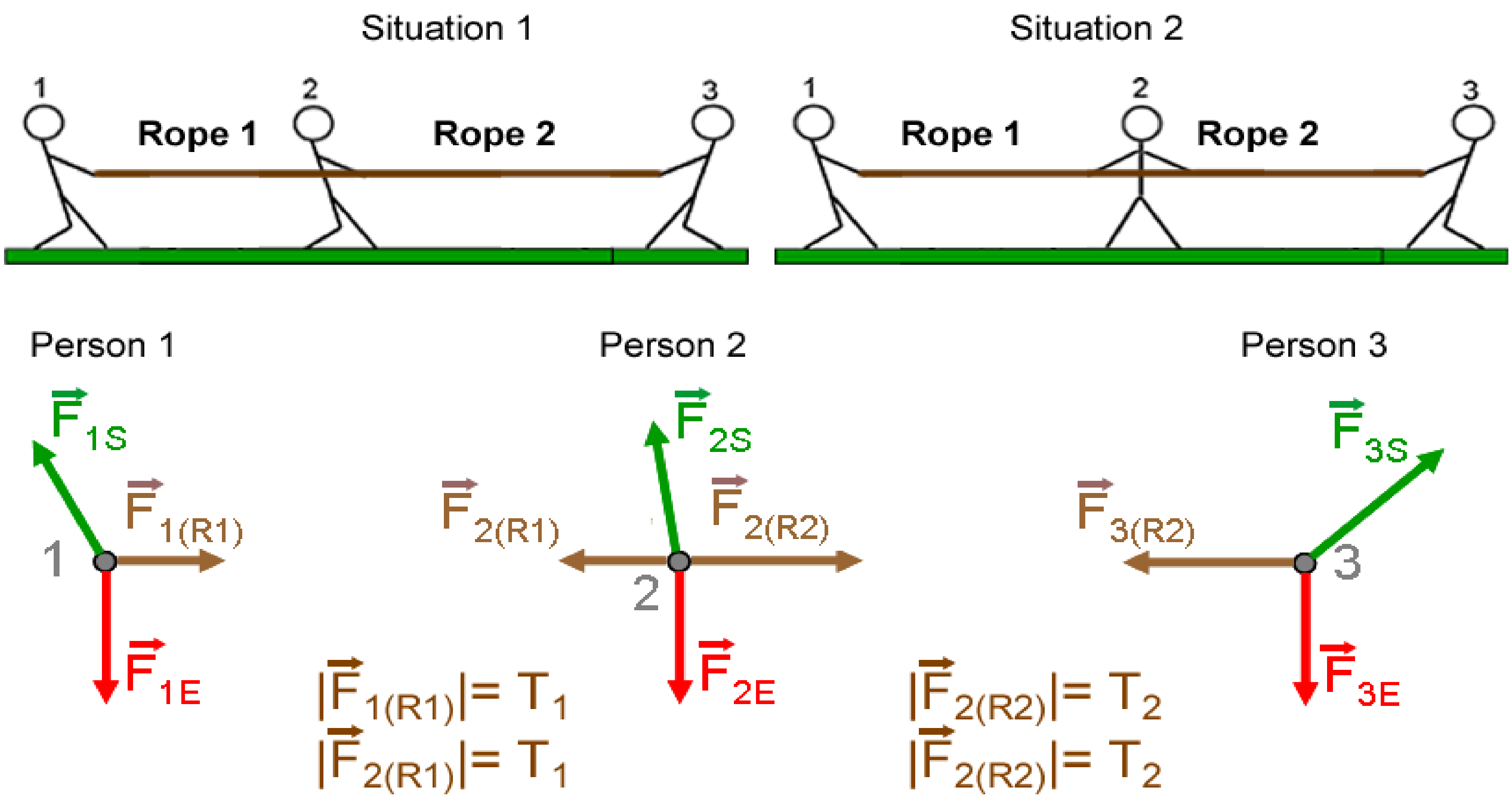
Massless rope?

- What if the rope is a HUMONGOUS massive rope?
- Draw a section (has mass Δm) in the middle of such a rope under real tension…
- Draw a FBD of that section.

What do your FBDs look like?

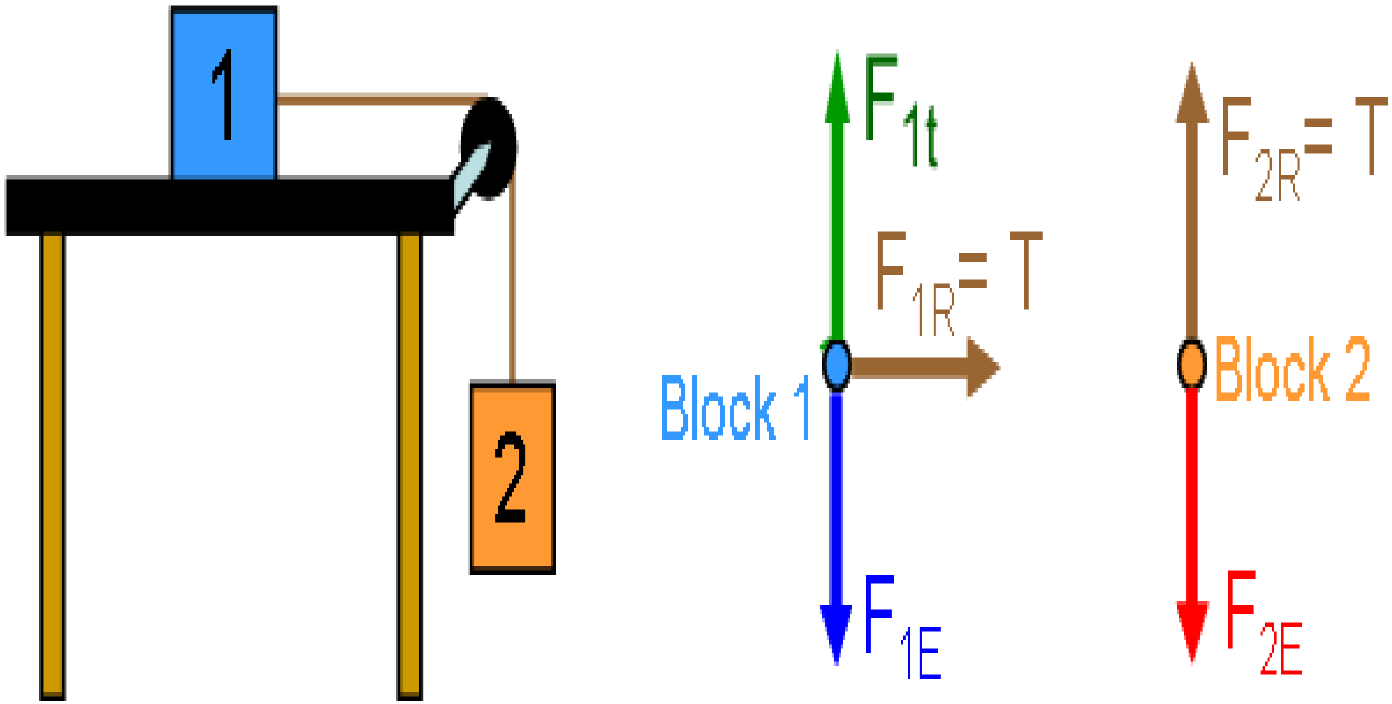
- Discuss the differences?
- What would it mean if you make the mass Δm get smaller and smaller….
- How about if you take the limit as $\Delta m \rightarrow 0$?
- That is what we mean by MASSLESS rope.

Pulling in the middle? Static equil.

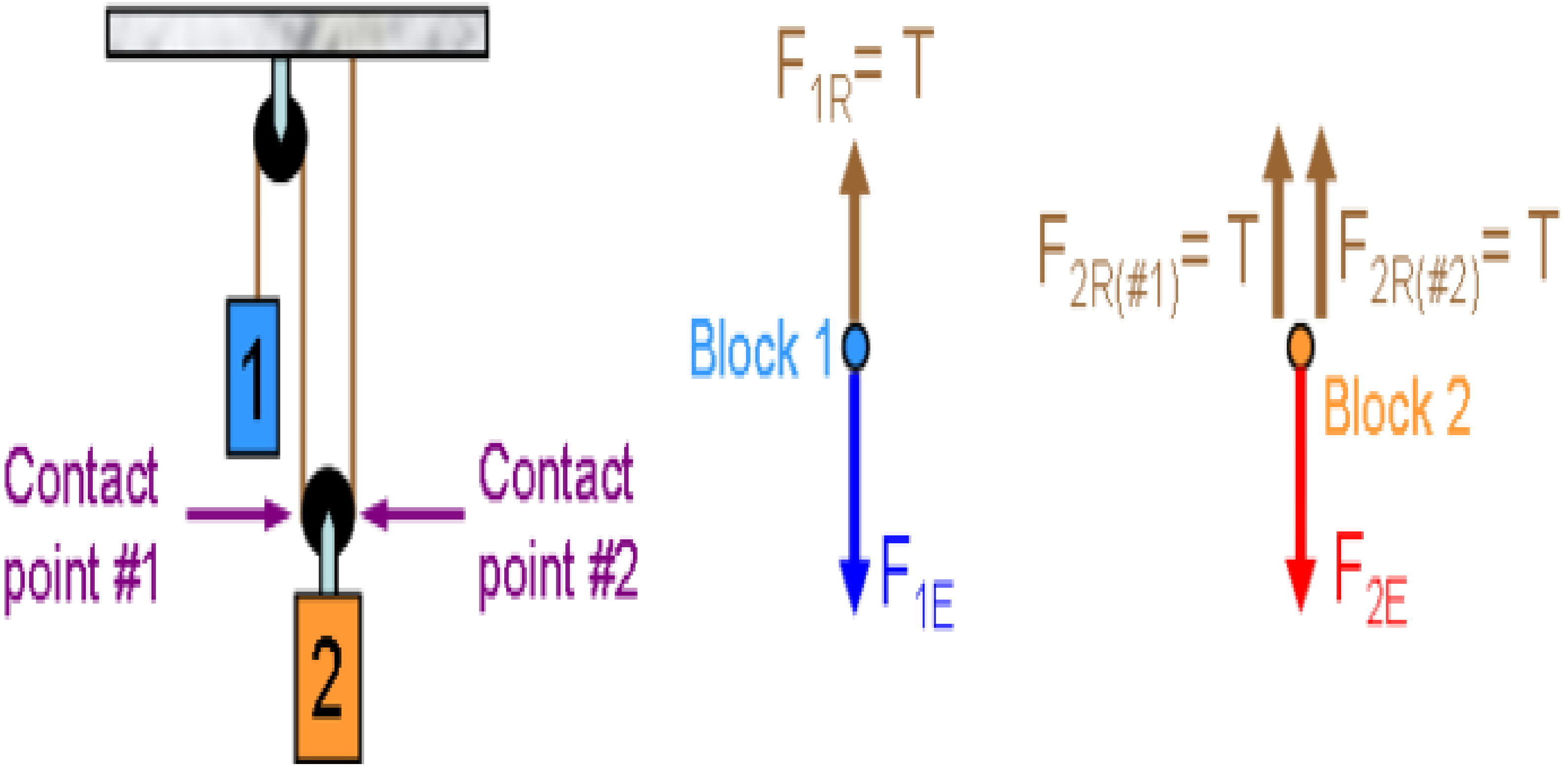


Note: simplifying notation… T   What must be true about the friction force on Person 1? What must be true about the normal force on Person 1?   (v=0 for everyone)

Pulleys…. Turn the force direction



Multiple pulleys… add more “contact” forces



Ranking Task…

- Sara… turn on the document camera…
- “2 different blocks and a pulley”
- Ok.