Newton's 3rd Law

Internal Forces

Dynamics

I. Newton's 3 Laws of Motion
   - inertia, force, mass, weight
   - interaction & nature of force

II. Normal Force

III. Compression, Tension, Sections

IV. Pulleys and Systems

V. Friction (between solids)

VI. Air Resistance

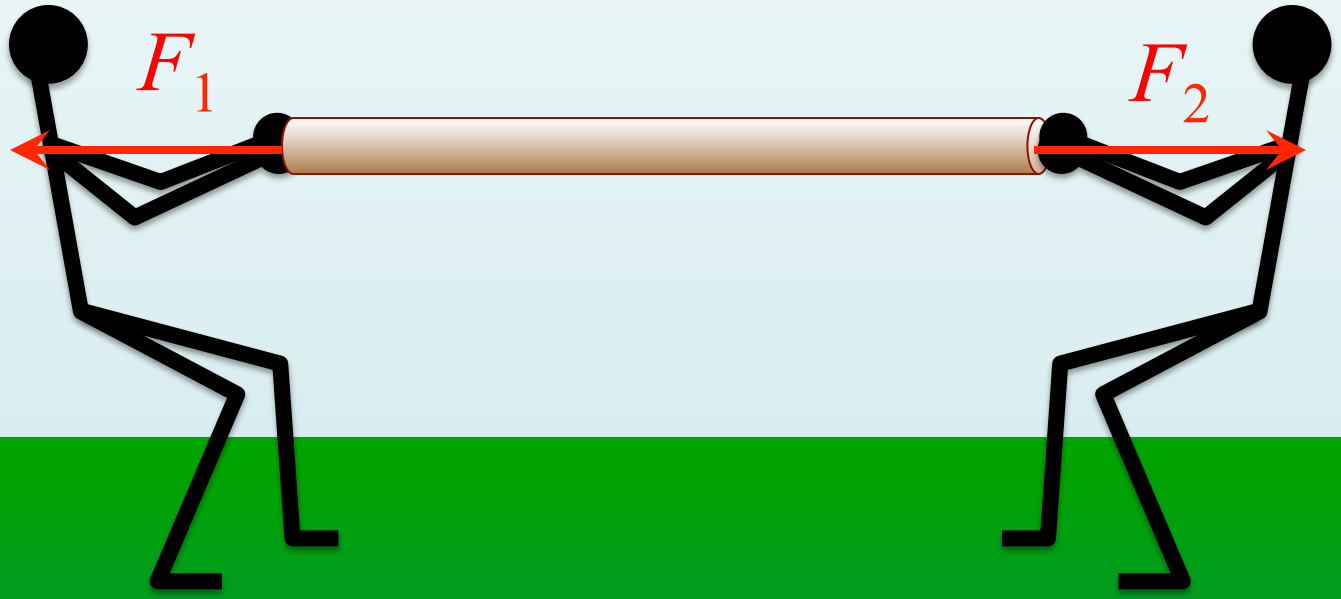
VII. Inclines, ramps, etc.

	The student will be able to:	HW:
1	State Newton's 1st and 2nd Laws of Motion and apply these laws to physical situations in order to determine what forces act on an object and to explain the object's resulting behavior. Define and apply the concept of inertia and inertial frame of reference. ✓	1 – 7
2	Recognize and state the proper SI unit of force and give its equivalence in fundamental units and use the relation $\mathbf{F}_{net} = m\mathbf{a}$ to solve problems. ✓	8 – 10
3	Recognize the difference between weight and mass and convert from one to the other. ✓	11 – 14
4	State and utilize Newton's 3rd Law to solve related problems. ✓	15 – 18
5	Understand and utilize the concept of the normal force to solve related problems. ✓	19, 20
6	Define and apply the concepts of compression and tension and use the method of sections to solve for these.	21 – 26
7	Solve force problems involving pulleys, including those involving multiple objects and systems of equations (such as Atwood's machine).	27 – 31
8	Understand and utilize the relation between friction force, normal force, and coefficient of friction for both cases: static and kinetic.	32 – 37
9	Solve problems involving air resistance in which friction is assumed directly proportional to velocity; define and apply the concept of terminal velocity.	38 – 39
10	Apply force components to objects on an incline and solve related problems.	40 – 44

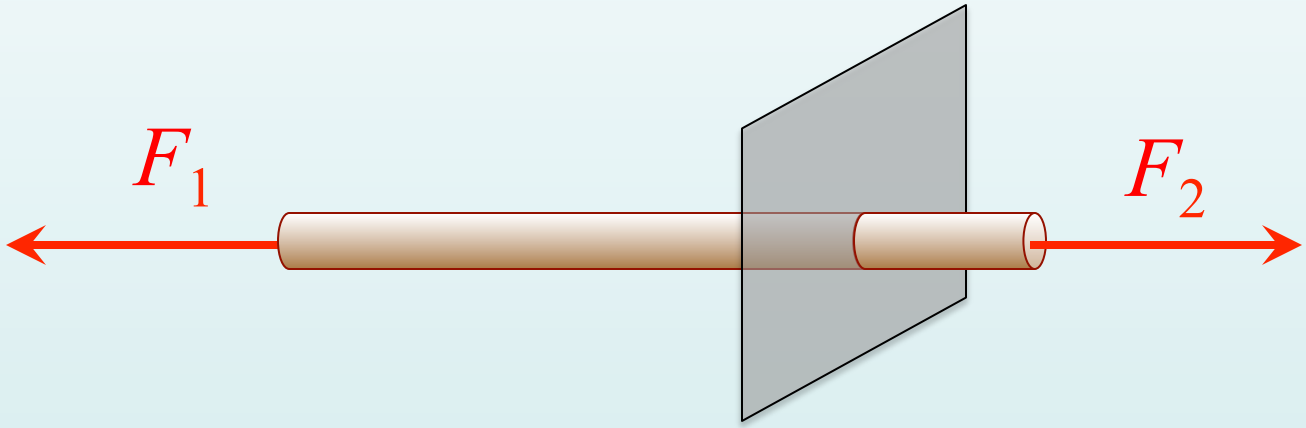
Method of Sections

- It is arbitrary what constitutes "an object". The "pieces" that make up an object may be considered separately.
- It is often helpful to draw a free body diagram for only a *part* (*i.e.* a piece) of an object.
- The object can be "sectioned" at an arbitrary location and forces that must exist "internally" are considered at that point.
- Newton's 3rd Law applies to forces between one piece of an object and the other piece at any section.

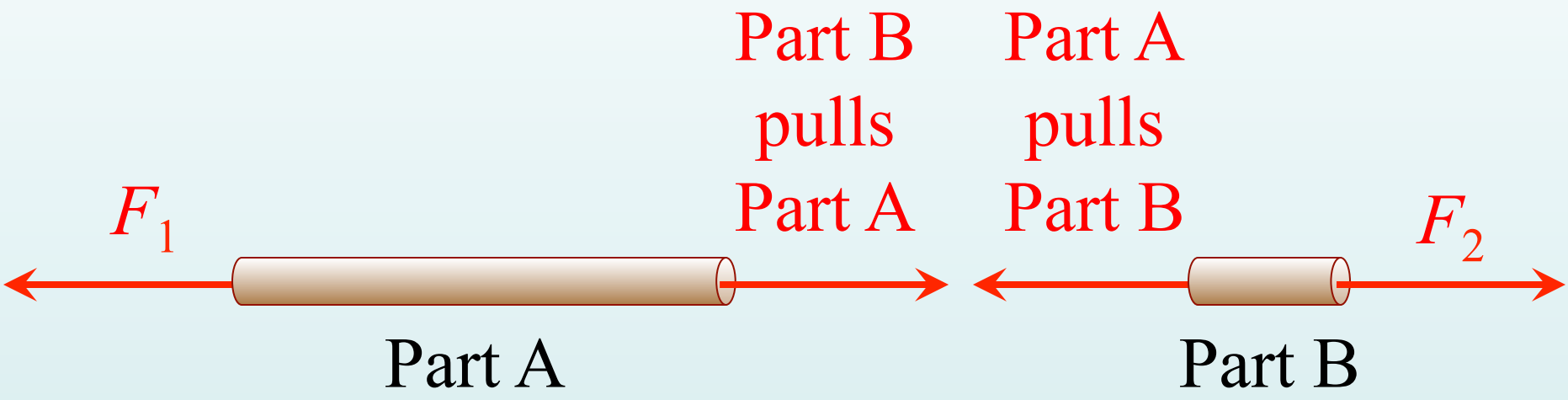
Suppose two people pull on a rod, each with force 100 N (like a tug-of-war). What is happening *inside* the rod?

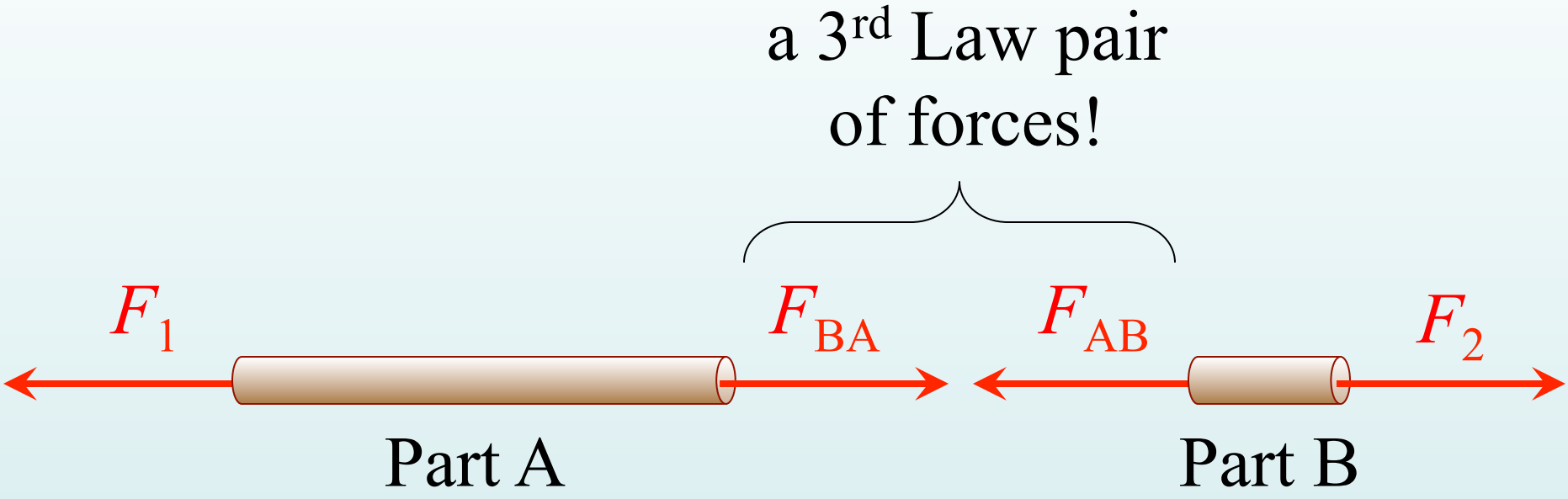


Imagine “slicing” (sectioning) the rod at an arbitrary location and then mentally separate it into two pieces:

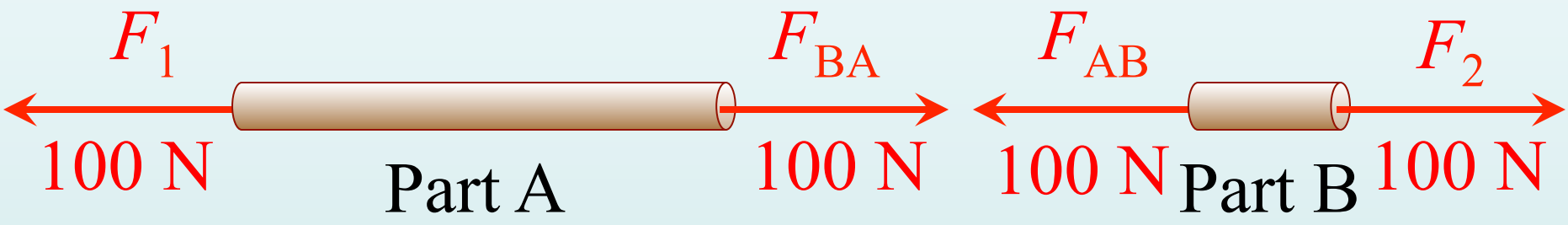


Newton's Laws must apply to these pieces of the rod just as the laws apply to the rod as a whole.

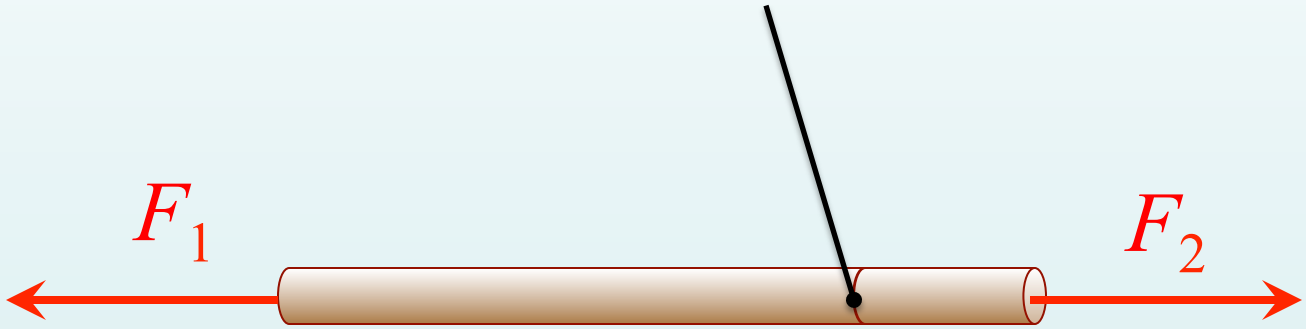


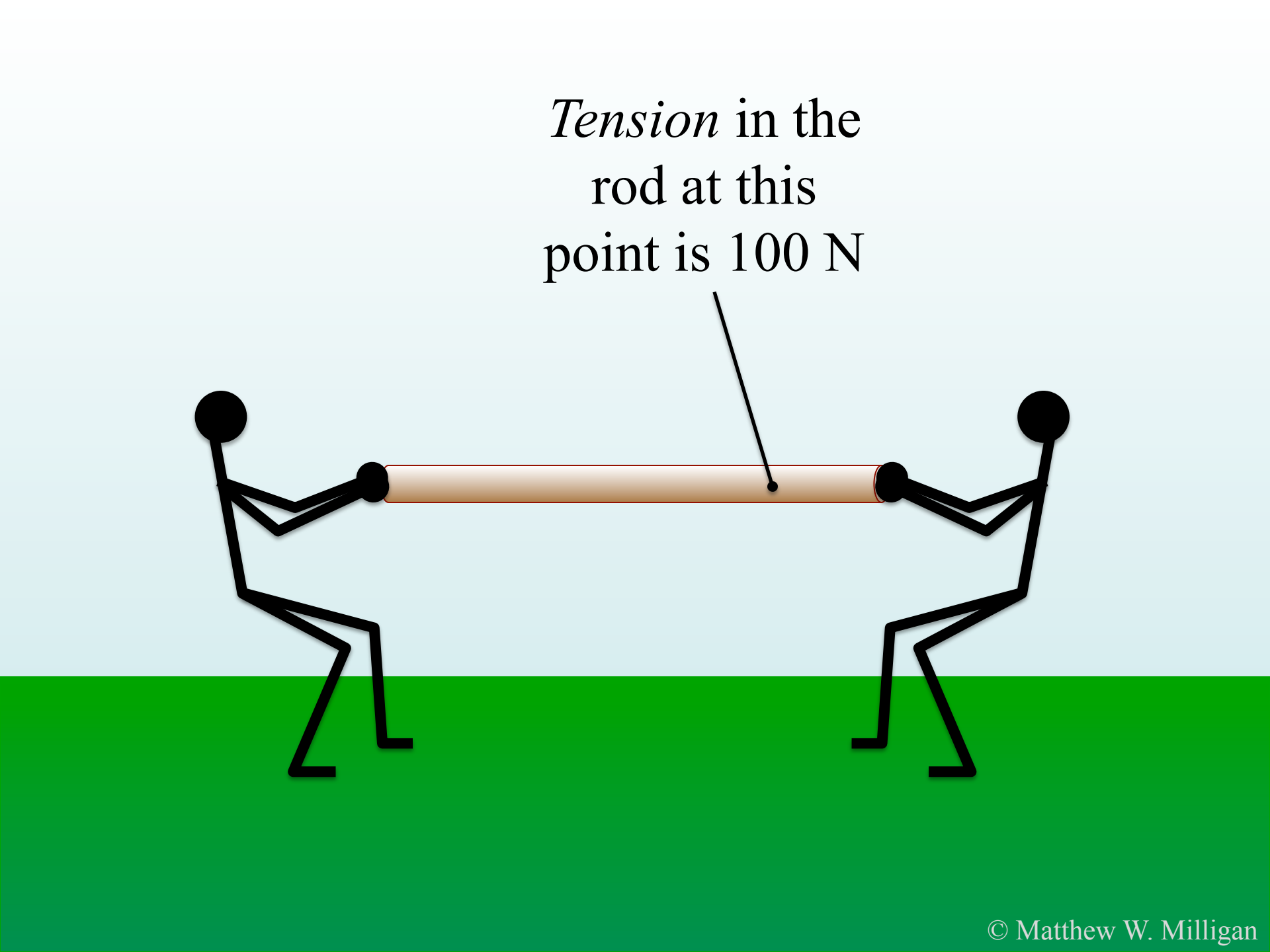


If each person pulls 100 N on the ends of the rod then the rod does not accelerate, nor does either piece. From this it is concluded the force inside the rod is also 100 N – otherwise the pieces would each accelerate.

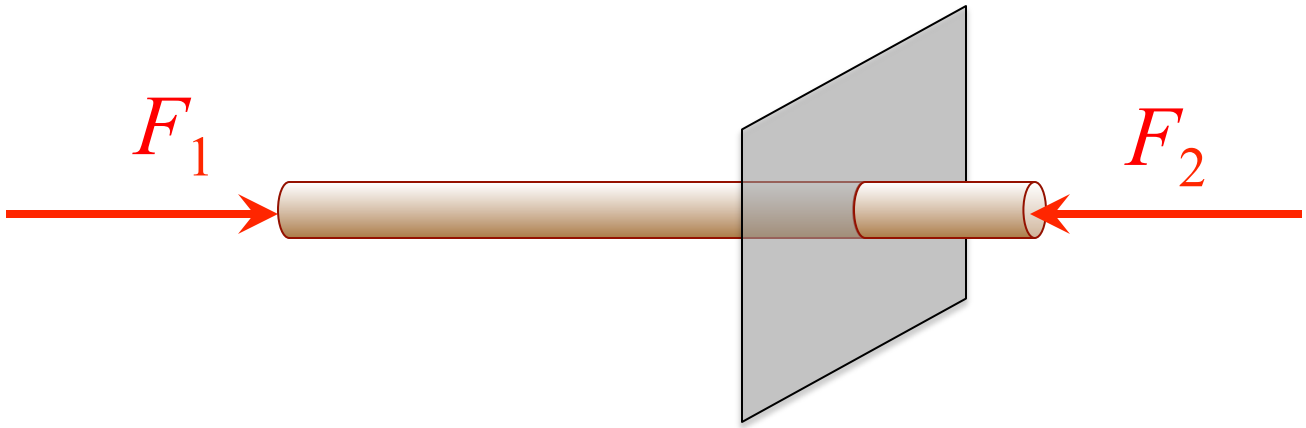


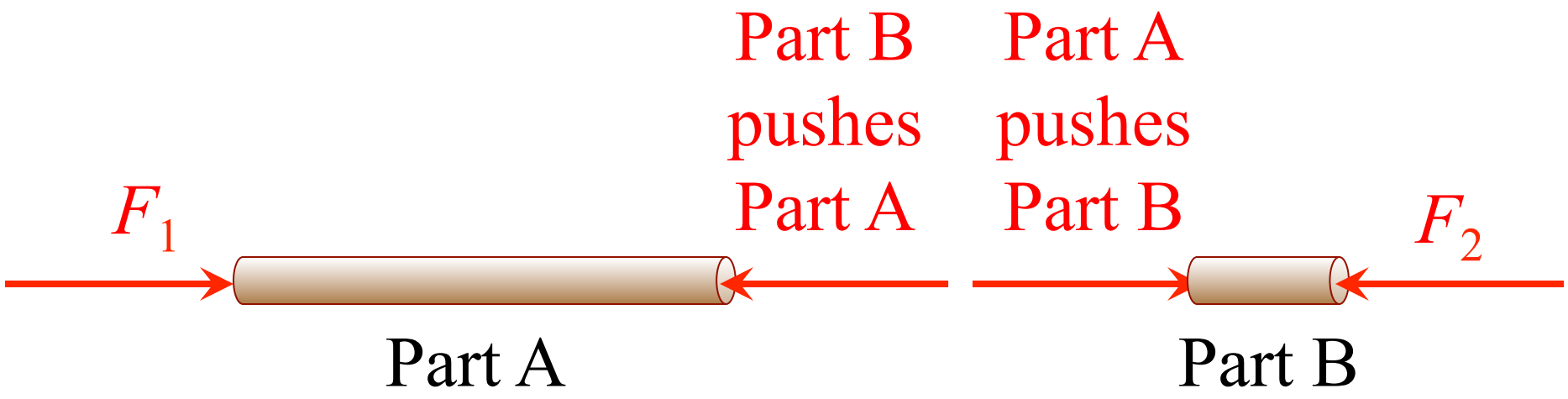
Tension in the rod at this point is 100 N

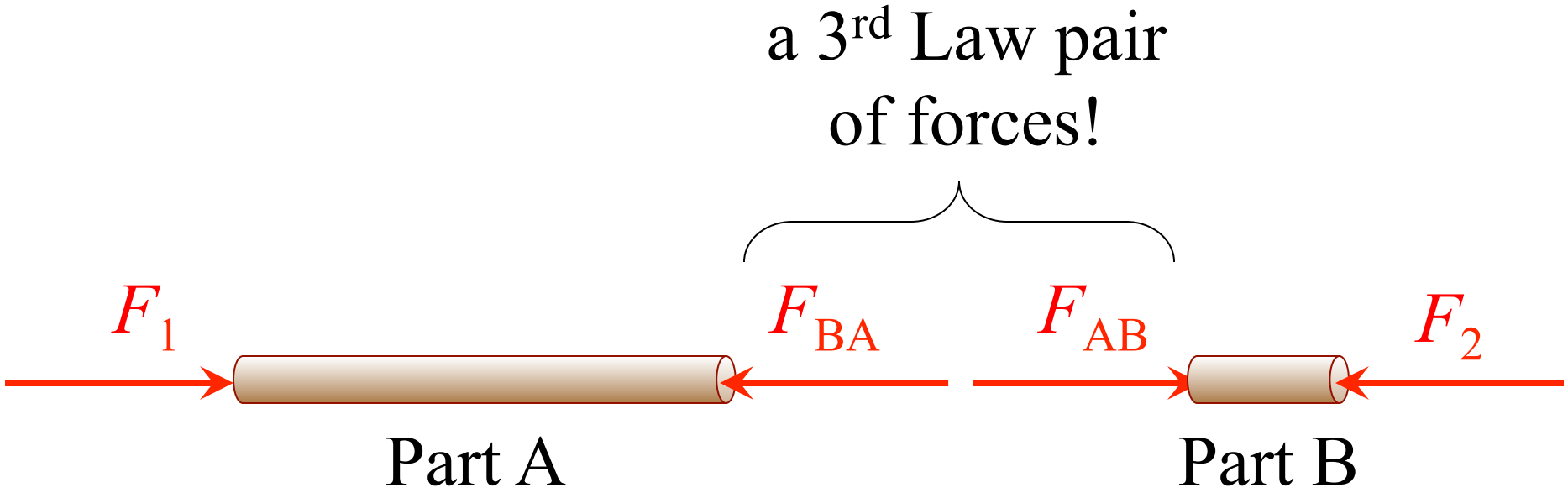


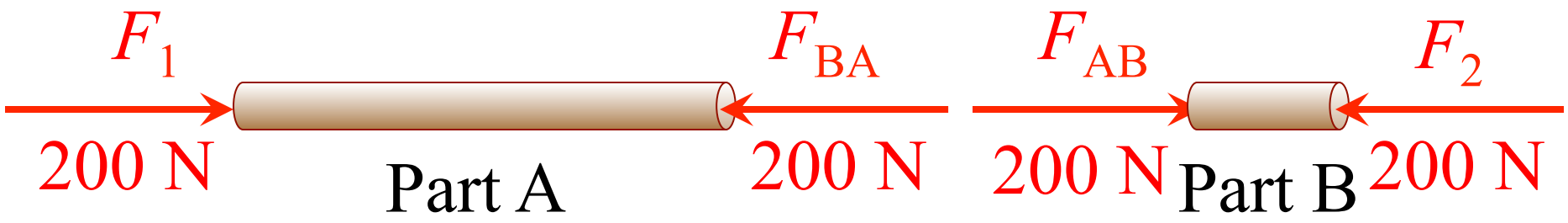


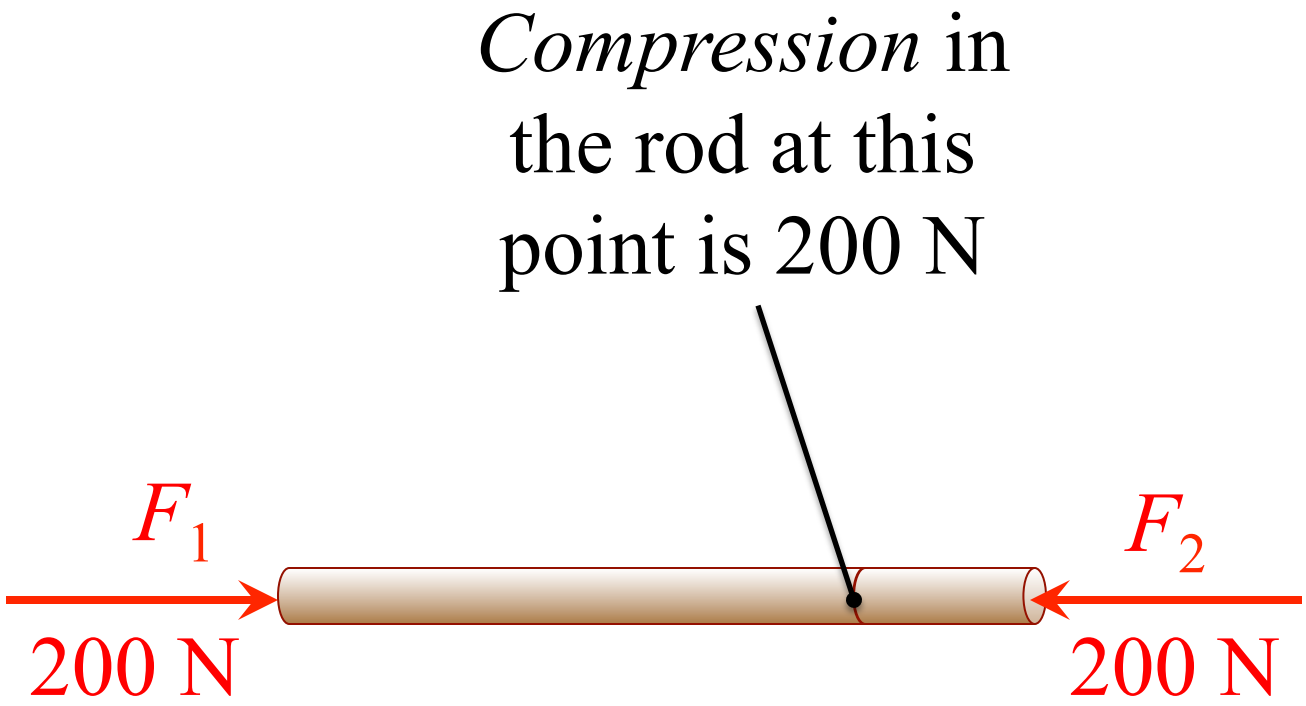
Repeat the process but now suppose each person is pushing on the rod with a force of 200 N.



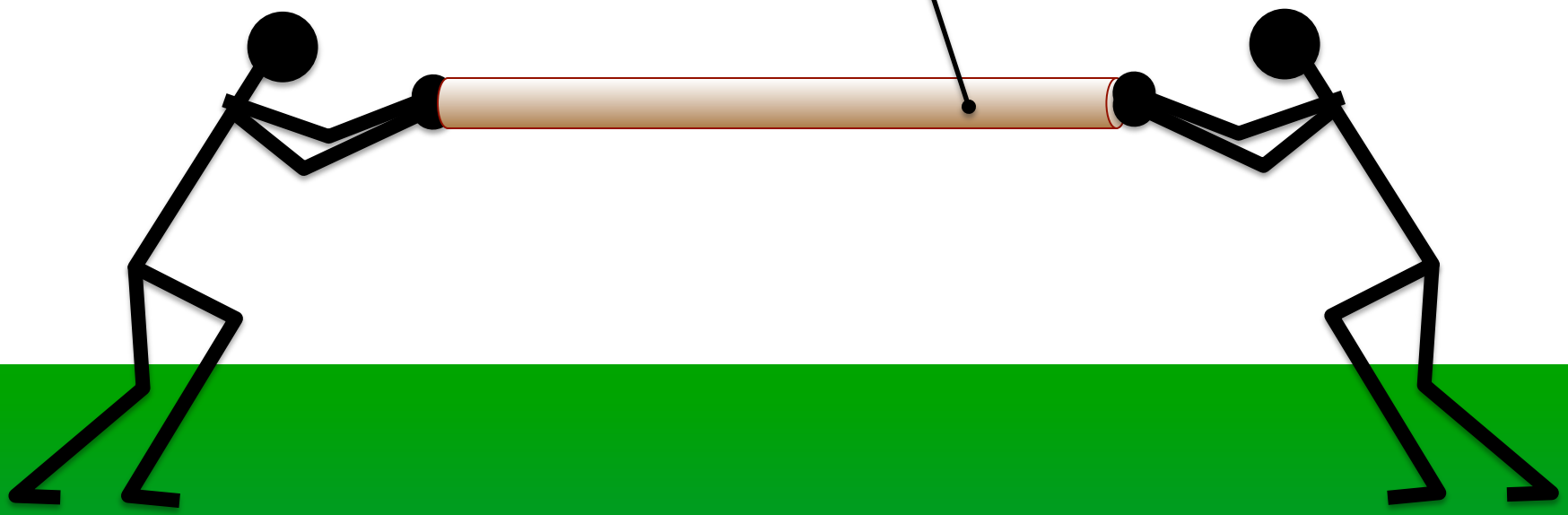








Compression in the rod at this point is 200 N



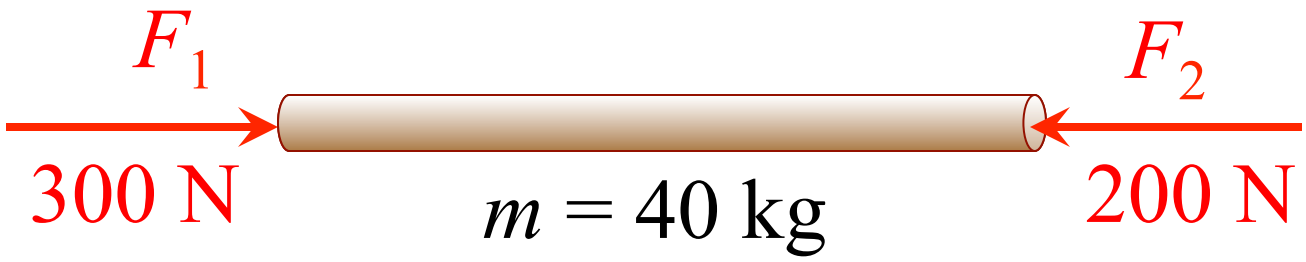
Now suppose that the person on the left is stronger, pushing more on the 40 kg rod than the person on the right – 300 N vs. 200 N.

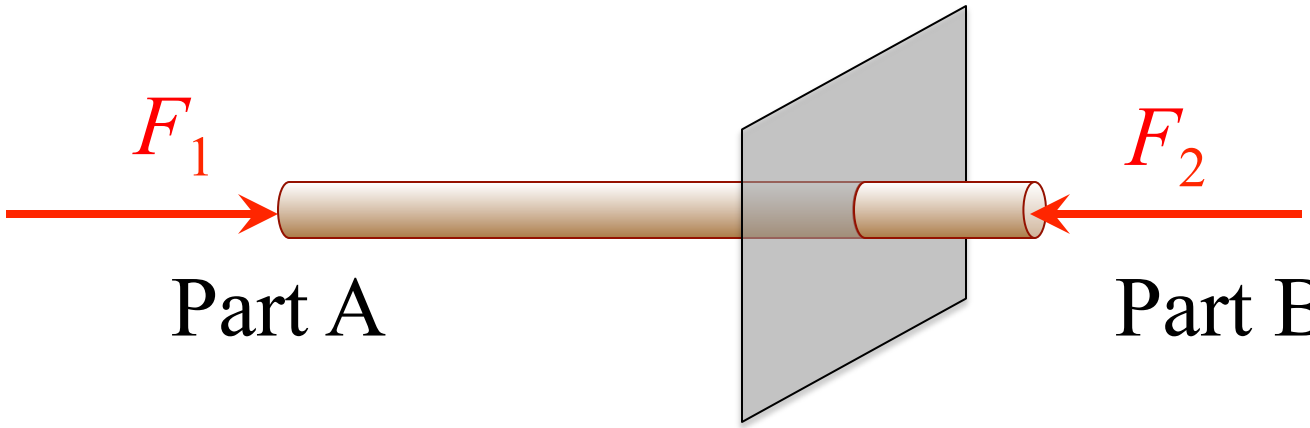
$$\Sigma F = ma$$

$$300 - 200 = 40\ a$$

$$100 = 40\ a$$

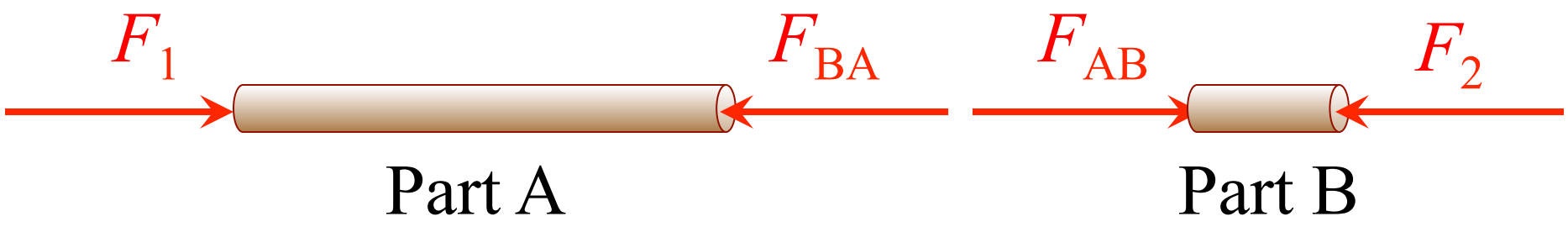
$$a = 2.5\ \text{m/s}^2, \text{ right}$$





This time both parts are accelerating!

$a = 2.5$ m/s^2, right



This time both parts are accelerating!

$a = 2.5$ m/s^2, right

$m_A = 30$ kg

$m_B = 10$ kg

$\Sigma F = ma$

$300 - F_{BA} = 30(2.5)$

$F_{BA} = 225$ N

$\Sigma F = ma$

$F_{AB} - 200 = 10(2.5)$

$F_{AB} = 225$ N

Compression in the rod at this point is 225 N as it is accelerating to the right at 2.5 m/s^2.