Tensions, Systems and Newton's Laws - Practice

Recall: When connecting objects with a string, there is a *single* value of the tension whenever:

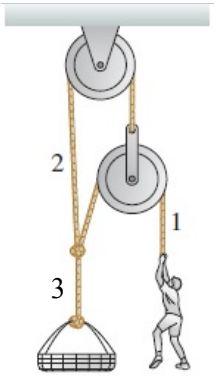
- The string is horizontal and in equilibrium; or
- The string is ideal (non-deformable and with negligible mass).

Before applying Newton's 1st or 2nd Law to a problem, make sure to:

- Clearly identify the system or object(s) of interest.
- Consider the forces external to that system.
- You may have to divide your problem into different systems and solve them separately.

Problem 1. Injured Climber

In rock climbing, various rope and pulley systems have been devised to help haul up heavy loads, including injured climbers. A rescuer is hauling up an injured climber who weighs 930 N using the rope and pulley system shown in the figure. (The ropes in this figure are drawn at various angles for clarity, but you can assume they're all vertical.)



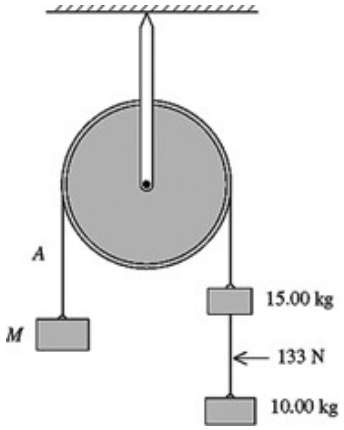
What are the tensions in the ropes and the rescuer's pulling force F_p.
[ans. $T_1 = (1/3)F_G$, $T_2 = (2/3)F_G$, $T_3 = F_G$, $F_p = T_1$]

Guiding questions:

- How many ropes are there?
- How does the tension T_1 compare to pulling force F_p?
- What is your system? Consider separately:
  (i) the injured climber (in the basket); (ii) the lower pulley; (iii) the upper pulley

Problem 2. Atwood Machine

Three objects are connected by massless wires over a massless frictionless pulley as shown in the figure. The tension in the wire connecting the 10.0-kg and 15.0-kg objects is measured to be 133 N. What is the mass *M*?



Guiding questions:

- How many ropes are there?
- What is your system? Consider separately:
  i. the 10-kg block
  ii. the 15-kg block
  iii. the block of mass *M*.

Problem 3. Two Blocks

The lower block in the figure is pulled on by a rope with a tension force of 20 N. There is friction between the lower block and the ground, and between the two blocks.

a. Sketch the FBD for each block.
b. How does the force that the 1-kg block exerts on the 2-kg block compare to the force that the 2-kg block exerts on the 1-kg block?
c. [later in semester] What is the acceleration of the lower block?