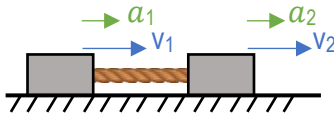


CONCEPT: FORCE PROBLEMS IN CONNECTED SYSTEMS OF OBJECTS (X-AXIS)

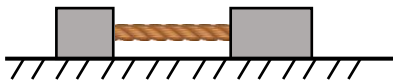
- IF objects are attached / connected to each other, they move together with same _____ AND _____.



$$= \Rightarrow a_{sys} = a$$

$$= \Rightarrow v_{sys} = v$$

EXAMPLE: Two blocks of mass 3kg and 5kg are connected to each other by a light (massless) string. Ignore all friction. If you pull the 5kg block horizontally with a constant force of 30N, calculate **(a)** the acceleration of both blocks; **(b)** the Tension on the string between the blocks



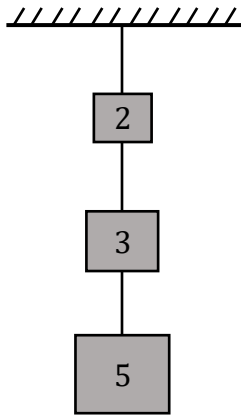
SYSTEMS OF OBJECTS

- 1) Draw FBDs for all objects
- 2) Choose direction of + (same as __)
- 3) Write $\Sigma F = ma$, starting with _____ (_____ Forces)
- 4) Solve **a** (EQ addition/substitution)
- 5) Plug **a** into equations, solve other targets

- To solve these problems, you can choose either equation _____ OR equation _____.

- **EQ Addition**: line up equations top-to-bottom, then add & eliminate the non-target variable.
- **EQ Substitution**: usually plug simplest equation into the more complicated to eliminate non-target variable.

PROBLEM: Three blocks hanging from the ceiling are all connected by massless strings. Find the magnitude of the Tension in **(a)** the top-most string, and **(b)** the middle string



SYSTEMS OF OBJECTS

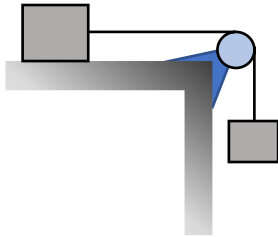
- 1) Draw FBDs for all objects
- 2) Determine direction of $+$
- 3) Write $\Sigma F = ma$, starting with simplest (fewest Forces)
- 4) Solve a (EQ addition/substitution)
- 5) Plug a into equations, solve other targets

- When objects hang by multiple ropes/strings, each tension has to support/pull the TOTAL weight _____ it.

CONCEPT: FORCES IN SYSTEMS OF OBJECTS WITH PULLEYS

- **Remember!** IF objects are connected to each other, they have the same acceleration AND velocity.
 - To determine direction of $+$, if only 1 object is hanging, $+$ is usually in the direction the _____ object will fall.
- For massless pulleys, the Tension on both objects points in *different* directions but has the _____ magnitude.

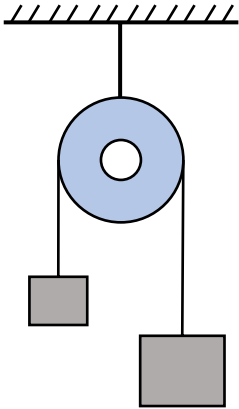
EXAMPLE: A 4kg block resting on a frictionless table is connected to a 2kg block hanging off the table by a cable and massless pulley. Calculate **(a)** the acceleration of both blocks; **(b)** the Tension on the string between the blocks



SYSTEMS OF OBJECTS

- 1) Draw FBDs for all objects
- 2) Determine direction of $+$
- 3) Write $\Sigma F = ma$, starting with simplest (fewest Forces)
- 4) Solve a (EQ addition/substitution)
- 5) Plug a into equations, solve other targets

PROBLEM: Two blocks are connected by a light cord passing over a pulley. This setup is known as an **Atwood Machine**. If the larger block is 6kg and the smaller is 4kg, find **(a)** the acceleration of the system and **(b)** the Tension in the cord.



SYSTEMS OF OBJECTS

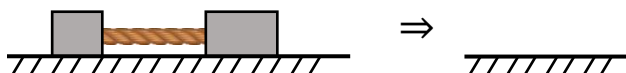
- 1) Draw FBDs for all objects
- 2) Determine direction of $+$
- 3) Write $\Sigma F = ma$, starting with simplest (fewest Forces)
- 4) Solve a (EQ addition/substitution)
- 5) Plug a into equations, solve other targets

- The direction of $+$ is usually the direction the _____ object will fall.

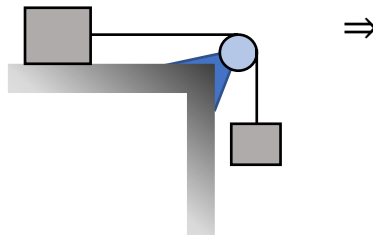
CONCEPT: COMBINING CONNECTED SYSTEMS OF OBJECTS INTO A SINGLE OBJECT TO SOLVE

- When solving for a , a useful shortcut is to _____ all masses ($m_A, m_B, \dots$) $\rightarrow$ single object ($M = m_A + m_B \dots$).
 - When doing this, ignore any Tensions or Normals _____ the objects (i.e any connecting forces).

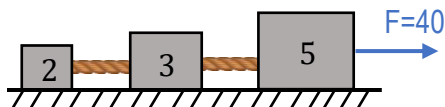
EXAMPLE: A 3kg and 5kg block are connected by a string. If the 5kg is pulled to the right with 30N, calculate the acceleration of the system.



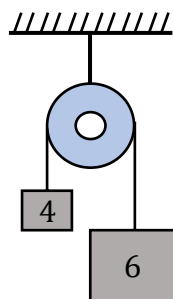
EXAMPLE: A 4kg block is connected via rope and pulley to a 2kg block hanging off a table. Calculate the acceleration of the system.



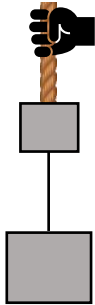
EXAMPLE: Calculate the acceleration of the system.



EXAMPLE: Calculate the acceleration of the system.



PROBLEM: Two blocks connected by a string are pulled vertically upwards by a thick rope with a force of 100N. If the larger block is 3kg and the smaller block is 2kg, calculate the acceleration of the blocks and the Tension in the connecting string.



- When using the shortcut, if asked for a connecting/"internal" force, draw a FBD and write $\Sigma F = ma$ for the _____ object.