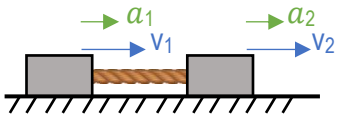
CONCEPT: FORCE PROBLEMS IN CONNECTED SYSTEMS OF OBJECTS (X-AXIS)

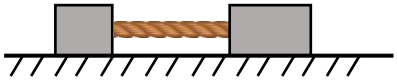
● IF objects are attached / connected to each other, they move together with same _____ AND _____.



$= \Rightarrow a_{sys} = a$

$= \Rightarrow v_{sys} = v$

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



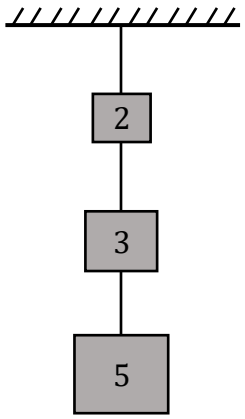
SYSTEMS OF OBJECTS

1) Draw FBDs for all objects
2) Choose direction of **+** (same as __)
3) Write **ΣF=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

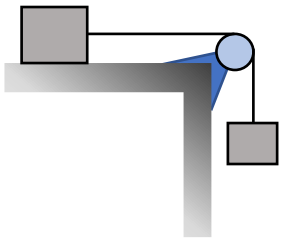
1) Draw FBDs for all objects
2) Determine direction of **+**
3) Write **ΣF=ma,** starting with simplest (fewest Forces)
4) Solve **a** (EQ addition/substitution)
5) Plug **a** into equations, solve other targets

● 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
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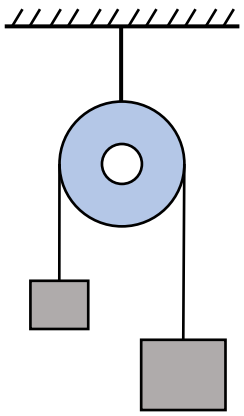
4) Solve **a** (EQ addition/substitution)
5) Plug **a** into equations, solve other targets

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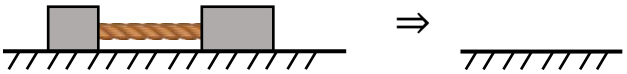
- The direction of **+** is usually the direction the _____ object will fall**.**

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

- When solving for $\boldsymbol{a}$, a useful shortcut is to _____ all masses ($\mathbf{m_A}$, $\mathbf{m_B}$,…) → *single* object ($\mathbf{M=m_A+m_B…}$).
  - 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.



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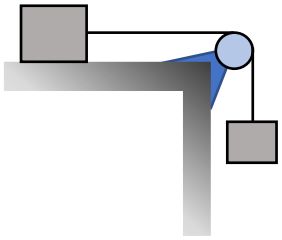
EXAMPLE: A 4kg block is connected via rope and pulley to a 2kg block hanging off a table. Calculate the acceleration of the system.



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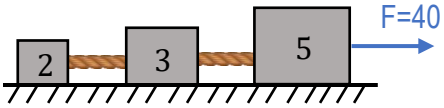
EXAMPLE: Calculate the acceleration of the system.



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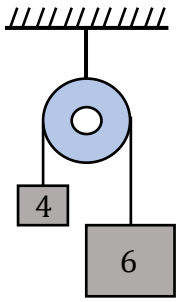
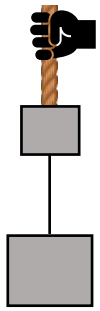


PROBLEM: Two blocks connected by a string are pulled vertically upwards by a thick rope with a force of 100N. If the larger block is 3kg and the smaller block is 2kg, calculate the acceleration of the blocks and the Tension in the connecting string.



● When using the shortcut, if asked for a connecting/"internal" force, draw a FBD and write **ΣF=ma** for the _____ object.