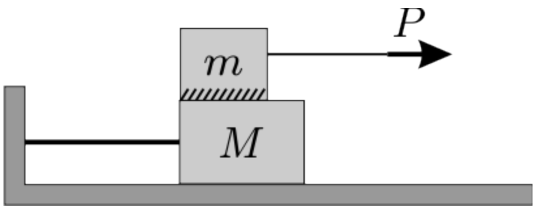
NEWTON'S LAWS OF MOTION

1. **Action Reaction Pairs:** Which of the following pairs are action-reaction pairs, and which are not? Explain your answers.
   (a) The Earth attracts a brick, the brick attracts the Earth.
   (b) A donkey pulls forward on a cart, accelerating it; the cart pulls backwards on the donkey.
   (c) A donkey pulls forward on a cart without moving it, the cart pulls back on the donkey.
   (d) A donkey pulls forward on a cart without moving it, the Earth exerts an equal and opposite force on the cart.
   (e) The Earth pulls down on the cart; the ground pushes up on the cart with an equal and opposite force.

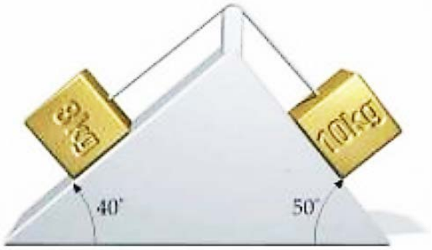
2. Block of mass M is placed on frictionless surface. It is connected to the wall using rope as it is shown on the figure. Top surface of the block is rough. Box of mass m is placed on top of the block. Light string is attached to the box and force P is applied to the string as it is show on the figure, but this force is not enough to start motion.



   (a) Draw free body diagram for the block and the box.
   (b) circle all action-reaction pairs

3. **Al and Bert**: Al and Bert stand in the middle of a large frozen lake (frictionless surface). Al pushes on Bert with a force of F for t. Bert's mass is m. Assume that both are at rest before Al pushes Bert.
   (a) What is the speed that Bert reaches as he is pushed away from Al?
   (b) What speed does Al reach if his mass is M?

4. **Blocks on an incline**: An 8.0 kg block and a 10 kg block, connected by a rope that passes over a frictionless peg, slide on a frictionless incline, as shown in the figure. Try using α and β for the angles instead of numbers!



   (a) Find the acceleration of the blocks and the tension in the rope.
   (b) The two blocks are replaced by two others of masses m_1 and m_2 such that there is no acceleration. Find ratio of the masses of these two new blocks.

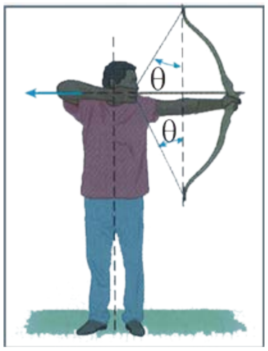
5. **Spatially varying force**: An object of mass m is at rest in equilibrium at the origin. At $t = 0$ a new force $\vec{F}(t)$ is applied that has components

$$F_x(t) = k_1 + k_2 y \qquad F_y(t) = k_3 t$$

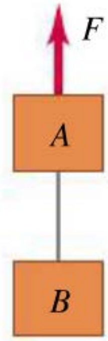
   where k_1, k_2, and k_3 are known constants. Calculate the position $\vec{r}(t)$ and velocity $\vec{v}(t)$ vectors as functions of time

6. **Horizontal Blocks.** Two blocks are in contact on a horizontal, frictionless surface. Block 1 has a mass of m and block 2 has mass of M. If an external force F pushes on block 1 what is the magnitude of the force that acts on block 2?

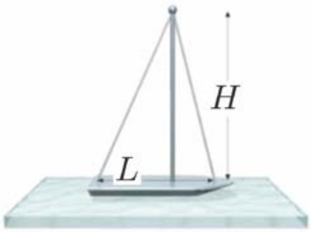
7. **Arrow.** An arrow of mass m is positioned in a bow as shown in the figure. If the tension in the bowstring in T calculate the acceleration of the arrow when it is released. Assume the angle that is shown is θ and the tension in the string is 100% transmitted to the arrow.



8. **Two blocks and a light rope**: Blocks A and B are connected to each end of a light vertical rope, as shown in the figure. A constant upward force F is applied to block A. Starting from rest, block B descends v in time t. The tension in the rope connecting the two blocks is T. What are the masses of block A and block B?



9. **Sailboat**: The mast of a sailboat is supported at the bow and stern by stainless steel wires, the forestay and backstay, anchored L apart, as shown in the figure. The H long mast weighs W and stands vertically on the deck of the boat. The mast is positioned Δx behind where the forestay is attached. The tension in the forestay is T. Find the tension in the backstay and the force that the mast exerts on the deck.



10. **Two blocks and a heavy rope**: The two blocks in the figure are connected by a heavy uniform rope with a mass of 4.00 kg. An upward force of 200 N is applied as shown.
    (a) Draw three free-body diagrams: one for the 6.00 kg block, one of the 4.00 kg rope, and another one for the 5.00 kg block. For each force, indicate what body exerts that force.
    (b) What is the acceleration of the system?
    (c) What is the tension at the top of the heavy rope?
    (d) What is the tension at the midpoint of the rope?