Calculating Unknown Masses

Draw an appropriate free-body diagram for each object. Use $\mathbf{F_{net}} = \mathbf{ma}$, show algebra and calculations, and include units. For connected systems, assume light, inextensible ropes and frictionless pulleys.

MILD

1. A box is pushed across a **frictionless horizontal floor** by a constant force of $\mathbf{8.0\ N}$, producing an acceleration of $\mathbf{2.0}\ m/s^2$. Determine the mass of the box.

2. A hovercart moves along a frictionless horizontal track. One thruster pushes right with $\mathbf{145\ N}$, while another pushes left with $\mathbf{35\ N}$. The hovercart accelerates **right** at $\mathbf{4.5}\ m/s^2$.
   a) Determine the net horizontal force on the hovercart.
   b) Calculate the mass of the hovercart.

MEDIUM

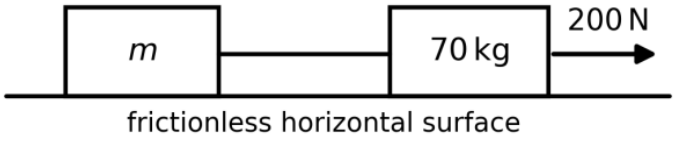
3. A winch lifts a bucket vertically. The cable exerts an **upward tension of $\mathbf{210\ N}$**, and the bucket accelerates **upward** at $\mathbf{2.3}\ m/s^2$. Determine the mass of the bucket.

4. A crane lowers a bucket vertically. The cable tension is $\mathbf{530\ N}$, and the bucket accelerates **downward** at $\mathbf{1.7}\ m/s^2$. Determine the mass of the bucket.

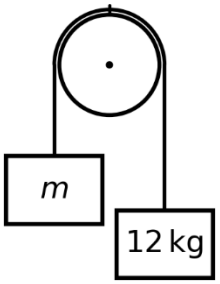
5. Sophia pulls a plastic traffic cone horizontally **to the right** across ice with a force of $\mathbf{15\ N}$. The coefficient of kinetic friction is $\boldsymbol{\mu_k} = \mathbf{0.18}$. While the cone is already sliding right, it accelerates to the right at $\mathbf{1.2}\ m/s^2$. Determine its mass.

SPICY

6. Two blocks are connected by a rope on a **frictionless horizontal surface**. The right-hand block has a mass of $\mathbf{70\ kg}$, and the left-hand block has an unknown mass m. A force of $\mathbf{200\ N}$ pulls the right-hand block **to the right**, producing an acceleration of $\mathbf{1.6}\ m/s^2$.
   a) Determine the unknown mass.
   b) Calculate the tension in the connecting rope.



7. Two masses, $\mathbf{12\ kg}$ and an unknown mass m, hang from a light rope over a frictionless pulley. The $\mathbf{12\ kg}$ mass accelerates **downward** at $\mathbf{1.5}\ m/s^2$.
   a) Determine the unknown mass.
   b) Calculate the tension in the rope.



8. A $\mathbf{4.5\,kg}$ block is **already sliding toward a pulley** across a horizontal table. It is connected to a hanging block of unknown mass. The coefficient of kinetic friction between the table and the block is $\boldsymbol{\mu_k = 0.30}$. The horizontal block accelerates toward the pulley at $\mathbf{1.8}\,m/s^2$.
   a) Calculate the tension in the rope.
   b) Determine the mass of the hanging block.

EXTRA-SPICY

9. A block of unknown mass m is **already sliding right** on a rough horizontal table. A rope over a pulley on the right connects it to a $\mathbf{5.0\,kg}$ hanging mass. The surface has $\boldsymbol{\mu_k = 0.20}$. The hanging mass accelerates **downward** at $\mathbf{1.4}\,m/s^2$.
   a) Determine the tension in the rope.
   b) Calculate the unknown mass on the table.

10. Two hanging masses are connected by a rope over a frictionless pulley. The heavier mass is $\mathbf{4.8\,kg}$, and the lighter mass is unknown. Released **from rest**, the heavier mass falls $\mathbf{1.25\,m}$ in $\mathbf{1.10\,s}$.
    a) Determine the acceleration of the system.
    b) Calculate the mass of the lighter object.
    c) Determine the tension in the rope.