Free-Body Diagrams (FBD)

A FBD is a picture that illustrates all of the forces acting on a particular object. The object is "free" from its environment, as only the forces are shown. FBDs are essential in Mechanics and will be **required** for all of your solutions to Dynamics (Newton's Laws) problems.

Steps:

1. Isolate the object being analyzed.
   Identify ALL forces that act ON the object; NOT the forces it exerts on its surroundings.

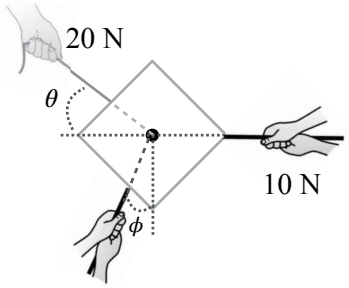
2. Draw a *convenient* coordinate system.

3. Represent the object as a dot at the origin, when possible (particle model).

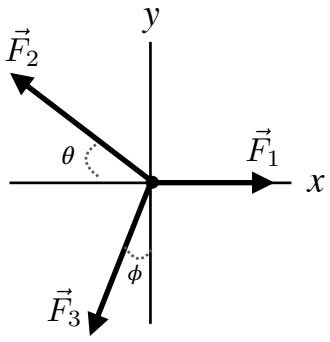
4. Draw **vectors** representing each of the identified forces.
   (Tail of each force vector on the object. Illustrate angles.)

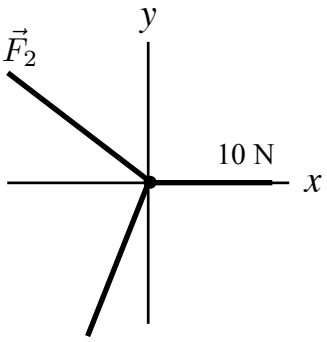
Free-Body Diagram Sketching: Dos and Don'ts

Example: top view of a box pulled by three ropes.



FBDs:





✓ **DOs:**

- Represent forces with vectors (arrows)
- Label each vector with a symbol
- Illustrate the angles wrt the coordinate axes
- Place the tail of the vector on the object (dot)

✗ **DON'Ts:**

- Represent forces with lines without arrowheads
- Label vectors with values, or leave unlabeled
- Forget to identify the angles
- Place the tail of the vector at random locations

Second (Components) Free-Body Diagram

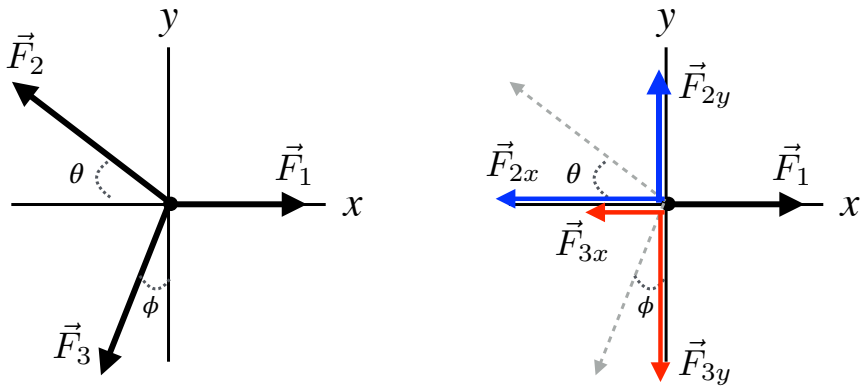
If there are vectors not aligned with the axes in the first FBD, draw a second FBD where the non-aligned vectors are decomposed ("broken") along said axes.

This Second –or Components– FBD is a like copy of the first one:

- it must follow the same orientation of the axes; and
- it must include all force vectors.

The only difference between the two FBDs is that the latter illustrate the *component vectors* of the non-aligned vectors.

(First FBD) (Second FBD)



Component Vectors:

After sketching the Components FBD, determine the *magnitude* of the component vectors in terms of the original vector magnitudes and the angle(s), that is, use trigonometry.

For example:

$F_{2y} = F_2 \sin\theta$

$F_{3y} = F_3 \cos\phi$

Note:

- $\vec{F}_{2x}$ and $\vec{F}_{2y}$ are called the "component vectors" of $\vec{F}_2$, while their magnitudes are simply referred to as the "components".
- These (trig) relations only hold for the *magnitudes* or components, not the vectors themselves. Do not cap these vectors/component vectors with arrows.