Analyzing the Forces in a System

For each object of interest in the problem:

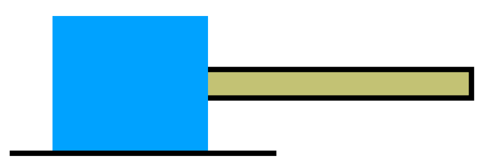
1. Make a list of the forces acting on that object.
   a) Start with weight (if applicable).
   b) Any pulling on the object (as by a rope) is tension.
   c) Any surface in contact may supply a normal force or a frictional force or both. If the surfaces are sliding against each other then it is kinetic friction; if not, it is static friction.

2. Draw a force diagram of the object with all the forces labelled, either with their value (if given) or with a distinct variable name. (Use subscripts if there are, for instance, more than one normal force).
   a) Weight points down.
   b) Tensions point in the direction of the rope or pull
   c) Normal forces always point towards the object, perpendicular to the surface of contact.
   d) Kinetic frictional forces point along the surface, opposite the direction of motion.
   e) Static frictional forces point along the surface, in whatever direction is necessary to maintain equilibrium. If you cannot determine the direction of the static friction, just pick one at random.

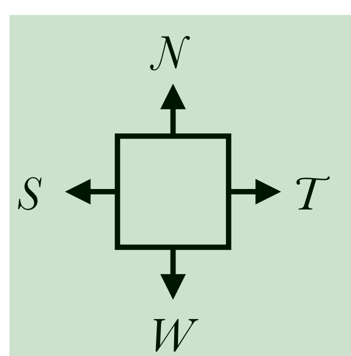
3. Define the positive x and y directions by drawing an axis.

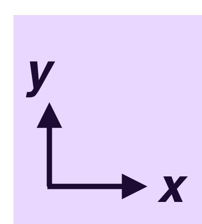
4. Next to the list you wrote in Step 1 draw two columns, for x and y. Write the components of each force in the table next to the force's name:
   a) If the force points along one of the axes, put a dash in the other column.
   b) If the force does not point along one of the axes but at an angle, then you will need to break it down into its components. If the magnitude of the force is X, then write "X cos (angle)" in the column corresponding to the direction the angle is measured from; the other column gets "X sin (angle)"
   c) Write a + or a – in front of each entry indicating whether it points in the positive or negative direction. You may omit the sign if you don't know the direction the force points.

Example: A 8N block is being pulled on by a rope but does not move.



Weight	——	–8
Tension, rope	T	——
Normal, floor	——	N
Static friction, floor	$-S$	——





Solving Force Problems

1. Start by analyzing the forces in the system. (See previous worksheet.)
2. For each column of the tables, write the sum of the elements in that column.
   a) If the object is stationary or moving at a constant velocity, set each sum equal to zero.
   b) If the object is accelerating and you know the acceleration, set the sum equal to the mass of the object times the corresponding component of its acceleration.
   c) If you don't know if the object is accelerating or not, set the sum equal to ma_x or ma_y where m is the mass and a is the unknown acceleration.
3. If there are multiple objects in the problem, use Newton's Third Law to write additional equations. For example, if N_{BA} is the force of B on A and N_{AB} is the force of A on B, then you can count $N_{BA} = N_{AB}$ as an equation.
4. If the number of equations is equal to the number of unknowns, then you will be able to solve for all the unknowns using algebra. If there are fewer equations, then you might be able to solve for some of the unknowns, but not all of them.

Example: A 8N block is being pulled on by a rope but does not move.

Weight	——	-8
Tension, rope	T	——
Normal, floor	——	N
Static friction, floor	$-S$	——

$$T - S = 0$$

$$-8 + N = 0$$

5. If the question asks whether an object will slide, you can get away with one fewer equation than unknown. Solve for the static frictional force S and the normal force N, substitute them into the inequality $S \leq \mu_S N$, and then solve the inequality for whatever is needed.

If the coefficient of static friction is μ_S = 0.6, what is the largest value the tension can have before the block slides?

$$S = T \qquad S \leq \mu_S N \qquad N = 8$$

$$T \leq (0.6)(8)$$

$$T \leq 4.8\text{N}$$