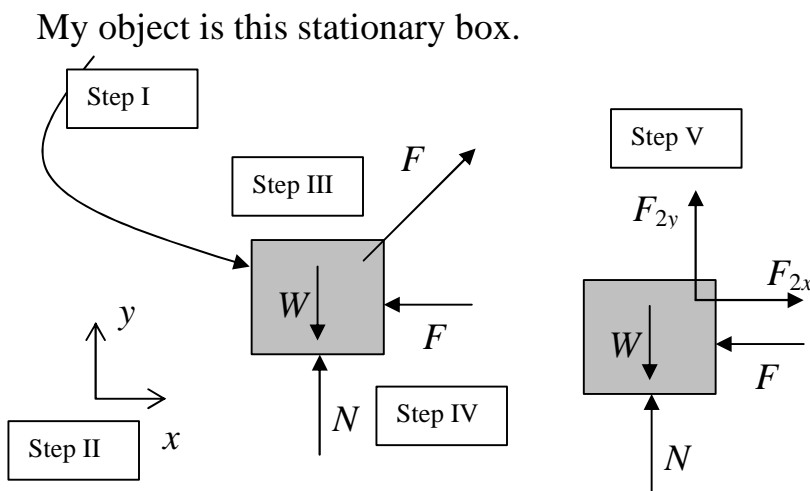## *How to Use Free Body Diagrams to Do Your Homework for You*

I: Choose an Object. Be ridiculously specific. Write an English sentence telling me what the object is.

II.   Draw a coordinate system. Especially be clear about which directions go which way.

III.   Draw a sketch of **just** your chosen object, without any other junk near it.

IV.   Draw and **name** all forces *that act on your object*. Each force must have a unique symbolic name: W_D, or N_B, etc.

V.   If some of your forces are oriented diagonally with respect to your coordinate system, start over again at step III. *You may not erase your earlier version*! In the new version, instead of each "diagonal" force, draw two separate forces, each of which is a component of the "diagonal" force. All the same forces should be on this diagram as were on the original, except that a few will now be there in component form.

VI.   <u>Write</u> Newton's 2nd law for each possible component direction, symbolically. If a force was drawn in the same direction as a coordinate axis, it is positive when you include it in ΣF, otherwise it is negative. When you're done, you should have two equations on your paper (for 2D problems. You'll have 3 equations for 3D problems).

VII.   Do algebra until you have solved for the item you wanted to know.

VIII.   Box your answer.

My object is this stationary box.

$\Sigma F_x = m\cancel{a_x} = 0$
$- F_1 + F_{2x} = 0$ Step VI   [1]

$\Sigma F_y = m\cancel{a_y} = 0$ Step VI
$- W + N + F_{2y} = 0$
$- mg + N + F_{2y} = 0$ [2]

Algebra:

Depending on what is known, you can solve for W, N, m, F_1, F_2, or even the angle at which F_2 acts.

How to Find Components of Forces in Steps V and VI

If a force is not parallel to one of your coordinate systems, you must replace it with its components in step V. Here's how to do it:

a. In a separate place from your Free Body Diagram, redraw the problem vector, but larger. In the example, the weight vector is the problem.
b. Using this vector as the diagonal, draw a box around this vector so that the sides are parallel to your coordinate axes.
c. The sides of the box are your components. Starting each at the same corner as your diagonal, label them with subscripts x and y.
d. Using either triangle in your sketch, label any angle you've been given. If, as in this example, the angle is not obvious, extend your drawing to include the given angle. Use the fact that the sum of the angles in every triangle adds to 180° until you've labeled an angle inside your chosen triangle.
e. Use sine and cosine to write expressions for your new components. In this example, $W_x = W\sin\boldsymbol{q}$.

$$\sin\boldsymbol{q} = \frac{W_x}{W}$$

$$\cos\boldsymbol{q} = \frac{W_y}{W}$$