**How to draw a free-body diagram – FBD**

A free-body diagram shows all the forces on an object. Each force is represented by an arrow. The length of the arrow shows the magnitude of the force and the arrow points in the direction in which the force acts. The tail of the arrow is connected to the system object and points AWAY from the object.

STEP 1: Identify the system – the **one** object whose motion you want to examine.

STEP 2: Draw the system object as a point or a box with no other objects shown.

STEP 3: Draw X-Y axes and assign + and – directions for each axis.

**IF the object is on a surface THEN draw the X-axis parallel to the surface.**

**IF the object in NOT on a surface THEN draw the X-axis horizontal.**

STEP 4: Determine which forces act on the object.

**Possible Forces**

(a) **Gravity** – Is the object at or near the surface of a planet? The planet will be Earth unless I specifically tell you differently. YES – Gravity acts on the object. NO – Gravity does not act on the object.

(b) **Normal Force** – Is the object in contact with a flat surface?

YES – There is a normal force. NO – There is no normal force.

(c) **Friction** – Is the object on a surface AND is the surface rough?

YES to both – There is friction on the object. NO to either – There is no friction.

(d) **Spring Force** – Is the object attached to a stretched or compressed spring?

YES – There is a force from the spring. NO – There is no force from a spring.

(e) **Tension** – Is there at least one nonrigid object (rope, string, chain, etc.) connected to the system object?

YES – There is a tension force due to **each** rope. NO – There are no tension forces.

(f) **Solid Object Contact Force** – Does some solid object push or pull on the system object? The solid object is NOT a supporting surface. That force is a normal force.

YES – There is a contact force for **each** object that pushes or pulls on the system object.

NO – There are no contact forces.

STEP 5: Draw and **label** the forces identified in step 3 acting on the system object you drew in step 2. The force

vector is drawn with its tail on the system object and its arrow pointing away from the object.

**In which direction does the force vector point?**

**gravity**  - The force of gravity or weight vector **always** points toward the center of the earth.

**normal force** – The normal force vector **always** points away from the surface and is perpendicular to the surface.

NOTE WELL – The normal force is only straight upward if the surface is level, perpendicular to

the force of gravity.

**friction** – The friction vector is **always** parallel to the surface that produces the friction.

For **sliding or kinetic friction** the vector will point opposite the direction in which the object moves.

For **static friction** the vector will point opposite the direction in which the object **would** move if there

were no static friction.

**spring force** – The spring force is directed parallel to the spring.

**compressed spring** – The spring force is away from the spring.

**stretched spring** – The spring force is toward the spring.

**tension** – The tension force of a rope is directed along the line of the rope and away from the system object.

The tension must always be a **pull**.

**contact force from solid object** - The direction of this force is determined by the situation described in the

problem.

These are general guidelines for drawing the free-body diagram. These guidelines may not cover every possible situation, but they will cover the great majority of the situations you will encounter.