Some of the Forces We Know and Love.

1. The Force due to Gravity (Fg) (take 1):

* The force of attraction between any 2 massive objects
* First we will take a simple and naïve look at gravity as the force that Earth (or another planet) exerts on another massive object.
* Fg points “down” and by “down” we mean “toward the centre of the planet”.
* The magnitude of Fg depends upon the mass of the object being pulled down and the strength of the gravitational field (g) on the planet.
* Also called ***weight***
* On Earth g=9.80N/kg. Meaning the Earth pulls down with 9.80N of force for every 1kg of mass.

$$F\_{g}=mg$$

 m is the mass of the object in kg

 g is the gravitational field strength (g=9.80N/kg on Earth)

2. The Normal Force (FN):

* When 2 solid objects come into contact they push each other apart. This force is called the Normal Force.
* The Normal Force is always *repulsive.*
* The Normal Force always acts perpendicular to the surfaces in contact.
* There is no formula. The normal force is as strong as it needs to be to prevent solid objects from passing through one another. This assumes that our solid objects are rigid and do not deform, and that they do not break.

3. The Frictional Force (Ff)

* Friction is the force that *resists slipping* between 2 surfaces.
* When 2 solid objects are in contact and the slide, OR ATTEMPT TO SLIDE, friction acts to prevent that sliding/slipping.
* Friction acts parallel to the surface.
* The direction of friction is always such that it will oppose SLIPPING. Friction DOES NOT always point opposite motion!
* To determine the direction of friction, it can be helpful to ask: “How would this object slide if there were no friction?” Then think that friction will OPPOSE SLIPPING.
* The magnitude of friction depends upon two factors:
* The relative “grippyness” or “slipperiness” of the two surfaces measured as a unitless coefficient called μ. Usually μ is between 0 and 1 (0< μ <1), but it can be greater than 1 in rare cases. A small value of μ means low friction or “slippery”, a large vale means high friction or “grippy”.
* How hard the two surfaces are pressed together. This is the Normal Force between the two surfaces.

$$0 \leq F\_{f} \leq μF\_{N}$$

4. The Force of Tension (FT)

* This is the force that exists in a (massless) string/rope/chain/cable that is pulled in opposite directions from both ends by 2 massive objects.
* Its magnitude is the same at all points along the string.
* Tension can only pull. This means it will point AWAY from the object at all points of contact.
* By using a pulley (massless/frictionless) ropes can allow forces to be applied around corners without losing strength.
* In most cases the mass of the string will be considered negligible relative to the masses of the other objects involved.

5. The Elastic/Spring Force (Fs)

* As the name implies this is the force applied by an elastic or a spring that has been stretched or compressed from its *natural* or *rest length.*
* We will assume our springs are massless and frictionless.
* The spring must be stretched or compressed by 2 massive objects at opposite ends of the spring.
* The magnitude of the force depends upon two factors:
* The strength of the spring. This depends on the material, the gauge, how tightly wound and many other factors. It is measured with a number called the *spring constant, k*, in units of N/m.
* How much the length of the spring has been *changed from rest length*.

$$F\_{s}=kx$$

 k is the spring constant in N/m

 x is the amount of stretch or compression in m.

* The direction of the force is RESTORATIVE. In other words the force will restore the spring will to its natural length.

Free Body Diagrams:

Drawing accurate free body diagrams (FBDs) is a critical skill for solving many dynamics problems. Most problems will ask for a neat, clearly labelled FBD.

An FBD is a diagram that is intended to simplify the problem by *freeing* the object you are studying from its surroundings and allowing us to focus on what is important: **THE FORCES ACTING ON THE OBJECT**.

There are some guidelines to help you draw a good FBD, but mostly you need to have a good understanding of the forces described above and a good understanding of Newton’s 3 Laws of Motion.

**GUIDELINES:**

* Keep it simple. Draw the object as a dot or a rectangle. The dot is actually meant to represent the *centre of mass* of the object.
* All forces are drawn as arrows (of course) that originate ON THE OBJECT and point outward.
* When possible try to draw the vectors to scale.
* If asked to produce a FBD for marks, draw only the actual forces, NOT THE COMPONENTS on the diagram.
* If you wish to indicate any other vector quantities, like velocity or acceleration, on the diagram, draw the separately, away from the object.

EXAMPLES:

1.

 constant velocity

This massive block is resting on a horizontal surface. The block is pushed to the right at a constant speed.

FBD: Reasoning: -Object has constant velocity so forces must balance (N1)

 -We know Fg always pulls down.

FN

 -Object is on horizontal surface, so FN must be vertical.

 -FN is repulsive so it must point up.

 -The applied force to the right is given.

 -The object is not accelerating; there must be a force to the left.

Ff

Fa

 -The object is sliding right, Ff will oppose sliding.

Fg

2. This object is at rest on this incline.

Ff

FN

 Reasoning: -Object is in equilibrium (at rest) on the incline → balanced forces

FBD: -Fg pulls down. Good ol’ gravity.
 -FN is repulsive, and perpendicular to the surface.

Fg

 -If there were no friction, the thing would slide down the incline, therefor friction must point up the incline.

 $\rightharpoonaccent{ν}$

3. This object is sliding UP the incline.

FBD Reasoning: -Object is NOT IN EQUILIBRIUM. This object will come to a stop.

Fg

FN

Ff

 -Fg is down. Good ol’ gravity.

 -FN is repulsive and perpendicular to surface.

 -Ff opposing sliding. The object is sliding up the incline so Ff must point down the incline.

 - Notice there is no force up the ramp. N1 says that we do not require a force in the direction of motion. We don’t why the object is going up the ramp, just that it is. Perhaps it had just slid down a huge frictionless hill? Maybe it was launched by a big spring?

4. FBD Reasoning: -Good ol’ gravity.

FT

Fg

 $\rightharpoonaccent{a}$ -FT since it’s a string.

 -FT > Fg because acceleration is

 up

Star, suspended from a string

on an upward accelerating elevator.

Write an Equation for FT in terms of $\sum\_{}^{}\rightharpoonaccent{F} = m\rightharpoonaccent{a}$ \*choose up as the positive direction

m, g and a. FT - Fg = ma I have put the signs on all vector quantities in this step

 FT – mg = ma

 FT  = ma + mg