Newton's Laws

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1 Newton's Laws

1.1 The 3 Laws

Law 1: Things have mass, and they sit still when net force is 0.

Law 2: $\Sigma F = ma$

Law 3: Push + pull = 0

1.2 Law 1

Mass is an abstract concept, artificially defined to measure how hard it is to move an object. Therefore, under a different scenario, it is possible to use another definition of mass. For now, we will look at every object as a point mass.

A point mass is an object without a shape.

1.3 Law 2

This is the only useful formula, with variations like:

$$a_{net} = \frac{\Sigma F}{m}$$
$$m = \frac{\Sigma F}{a_{net}}$$

Use this formula at your convenience.

1.4 Law 3

Just remember to draw a pair of arrows when drawing free body diagrams. This concept will be especially useful while understanding conservation of momentum.

2 Different Forces:

1. Normal Force: The force that prevents objects from falling through each other, a responsive force when surfaces push against each other.

$$F_N$$

2. Tension: The force transmitted through a string, rope, cable or similar one-dimensional continuous object.

$$T$$

3. Friction: The force that prevents objects from sliding past each other, a resistive force that always acts in the opposite direction to the motion.

$$f = \mu F_N$$

It is linearly proportional to the normal force, μ is called the coefficient of friction. μ can be dependent on the material of two surfaces, it can also change when the object is in static or kinetic. Usually $\mu_k < \mu_s$.

4. Gravity: The force that pulls objects towards each other. When the object is close to the surface of the Earth, the force is:

$$F = mg$$

However, when the object is far from the surface of the Earth, the strength of the force falls off by square of the distance from the center of the Earth.

$$F = -\frac{Gm_1 m_2}{r^2}$$
$$a_g = -\frac{Gm_1}{r^2}$$

G is the gravitational constant that can be interpreted as the strength of the force between two objects. Notice acceleration due to gravity is linearly proportional to the mass of the object.

5. Spring Force: The force that prevents objects from stretching or compressing a spring. It is linearly proportional to the distance of compression or stretching. The negative sign indicates that the force is always in the opposite direction to the displacement.

$$F = -k\Delta x$$

3 Question:

1. If all objects accelerate towards Earth at the same rate, why does it hurt more to be hit by an iron ball than to be hit by a football?