Newton's Second Law

Newton's Second Law of Motion relates the ideas of force, mass and acceleration. It can be expressed with a simple formula:

$$\text{net force} = \text{mass} \times \text{net acceleration}$$
$$F_{net} = m \cdot a$$

This formula will be the starting point for many problems, so it's important to know exactly what it means and how to use it.

There are often multiple forces acting on an object at the same time. The **net force** is the vector sum of all those forces. The **net acceleration** of an object is the instantaneous acceleration of the object at the moment we're considering. If the object is moving in a straight line, then acceleration follows that line.

We solve a Newton's Second Law question by considering each object affected by forces individually. We draw a **free-body diagram** for the object, sketching the forces involved, so we know what to add.

A CATALOGUE OF FORCES

Gravity. Gravity acts on all objects near the Earth's surface. (If the problem doesn't explicitly say we're in space, there's gravity!) The force of gravity is equal to the object's weight: **W** or $\mathbf{F_g} = mg$, where $g = 9.81$ m/s² is the acceleration due to gravity. You might be told to round to 10 m/s². Gravity always points straight down, never to the side.

Normal force. An object experiences a normal force ($\mathbf{F_N}$) when it's in contact with a surface which supports the object, such as a book on a table. The table exerts a force on the book to support it and stop it from falling. If we put too heavy an object on the table, then the table's structure can't provide enough normal force, and the table breaks. Normal forces are reactive rather than proactive: only enough is provided to balance any existing forces from other sources. Normal forces are always perpendicular to the surface that provides the force. For vectors, **normal** means "perpendicular".

Tension. Tension ($\mathbf{F_T}$ or **T**) is similar to normal force, but it's provided by ropes and strings. Ropes exert tension to keep from breaking. Tension is reactive also; it can't be calculated directly. Tension's direction points inwards along any section of rope, in two directions at once, and (assuming massless pulleys) the tension in a rope is the same everywhere. When multiple sections of the same rope exert a force on an object, each section exerts a force; the forces are cumulative.

Friction. When two objects are in contact with each other, and an external force is applied to create motion, the objects rub together. Friction is the force that resists motion because of rubbing. The magnitude of friction is determined partly by the materials the objects are made of, expressed as a **coefficient of kinetic friction** (μ_k) or, if all motion is prevented by friction, the **coefficient of static friction** (μ_s). Friction is

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