MODULE 16
INTRODUCTION TO EQUILIBRANT FORCES

In the previous chapters, motion was the star of the show: buses accelerating, balls flying, bicycles braking, and students occasionally running when the emergency assembly bell suddenly rings and everyone remembers that walking is no longer fast enough. But Physics has another equally interesting side: situations where *nothing seems to happen*. A book sits quietly on a table, a signboard hangs without drama, and you may be sitting perfectly still in class while appearing deeply attentive. Yet behind this peaceful appearance, forces are actually having a silent tug-of-war.

When forces balance each other, motion does not change. Not because forces disappeared, but because they cancel perfectly. At O-Level you met balanced forces in simple situations. Now at A-Level, we sharpen that idea with a powerful concept; the **equilibrant force**: *the single force that would exactly oppose all others and bring a system into equilibrium.* Engineers use it when designing bridges, pilots rely on it unknowingly during steady flight, and even your body depends on it just to stand upright without falling like an unplugged robot.

Do not worry if this sounds serious already; equilibrium may sound calm, but the Physics behind it is lively, elegant, and sometimes surprisingly funny. By the end of this chapter, you will not only understand why objects stay still or move steadily, but you will also begin to see balance everywhere; from classroom desks to skyscrapers… and perhaps even in your study habits (which, hopefully, will now include balanced revision!).

Welcome to the first chapter of **Particle Mechanics** where stillness finally gets the attention it deserves.

From Balanced Forces to the "Balance-Maker": Meet the Equilibrant

In O-level Physics, you learnt the comforting idea of **balanced forces**: *when forces cancel, the object does not accelerate*. A book on a table stays put because the downward weight is balanced by the upward normal reaction. A picture frame hangs peacefully because the tension in the string balances its weight. So far, so good; O-level teaches you how to *recognise* equilibrium.

Now A-level takes that familiar idea and upgrades it into a **tool**. Instead of only saying "the forces are balanced", we begin asking: *What single force would I need to add to make the body perfectly balanced?* That single "balance-maker" is called the **equilibrant force**. It is not a new mysterious type of force; it is simply the force that would exactly cancel the **resultant** (net force) of all the other forces.

Concisely: **The equilibrant force** *is the single force equal in magnitude and opposite in direction to the resultant of all other forces acting on a body.*

If the forces already balance, the resultant is zero and the equilibrant is also zero, meaning there is no extra force needed. But if the forces do not balance, then the equilibrant tells you exactly what to add (magnitude and direction) to restore equilibrium. This is why equilibrant forces matter in A-level Particle Mechanics: they help us analyse real situations like signboards, ladders, cables, cranes, bridges, and any object that must stay steady while forces pull in different directions including you, sitting on a chair, pretending you are not tired, while gravity quietly keeps pulling you downward.

RESULTANT FORCE VERSUS EQUILIBRANT FORCE

Before we talk about *equilibrium*, we must be fluent in the two "opposite twins" of force analysis: the **resultant** and the **equilibrant**. They are not enemies; they are simply two ways of describing the same situation, depending on whether you are *adding forces* or *cancelling forces*.

Resultant force (net force)

The **resultant force** *is the single force that has the same effect as all the forces acting together on a body.*

$$\text{Resultant force,} \mathbf{F_R} = F_1 + F_2 + F_3 + \ldots$$

Meaning: *if you replace all the separate forces by one force $\boldsymbol{F_R}$, the body would accelerate in the same way.*

Key idea:

- If $F_R \neq 0$, the body accelerates in the direction of F_R.
- If $F_R = 0$, the body has zero acceleration (it stays at **rest** or moves with **constant velocity**).

So equilibrium is simply the case when $\mathbf{F_R} = \mathbf{0.}$

Equilibrant force

The **equilibrant force** *is the single force that would bring the body into equilibrium by cancelling the resultant of all the other forces.*

$$\text{Equilibrant force,} F_E = -F_R$$

This means:

- F_E has the same magnitude as F_R.
- F_E acts in the opposite direction to F_R.

So if you apply the equilibrant, the new resultant becomes zero:

$$F_R + F_E = 0$$

Remember this:

- Resultant tells you: *"What is the overall push?"*
- Equilibrant tells you: *"What single push would cancel that overall push?"*

To have better understanding on this; suppose two forces act on a body:

- 12 N to the right
- 7 N to the left

Then, resultant force: $F_R = 12N - 7N = 5N$ to the right

And equilibrant force: $F_E = 5N$ to the left

So the equilibrant is the force that would make the body balanced.

For now, give theory a short holiday and let us sharpen our understanding with two worked examples.

BINDER example 1

A lamp is suspended from the ceiling by a vertical cord. The tension in the cord is 25 N upward while the weight of the lamp is 25 N downward.

(a) Determine the resultant force acting on the lamp.
(b) State the equilibrant force.

Solution

Upward force $= 25N$

Downward force $= 25N$

Resultant, $F_R = 25N - 25N$; $F_R = 0N$

(a) So the resultant force is 0N (the lamp is in equilibrium).
(b) Since the resultant force is zero, no additional force is required to balance the system.

$$\text{Equilibrant force} = 0N.$$

Making Sense of the Answer: *If forces already balance, the system is already in equilibrium. The equilibrant simply tells us that nothing extra is needed; balance has already been achieved.*

Thinking Like a Physicist: *Do not assume an equilibrant must always exist physically. Sometimes it is only a conceptual force used to check whether equilibrium already exists.*

REAL example 2

Kipute is sitting quietly on a chair revising Physics. She says: *"I am at rest because the upward force from the chair balances my weight."*

Kipanga disagrees: *"If gravity is pulling you downward, there must be a stronger downward force. Otherwise you would float!"*

Explain who is correct and clarify the roles of resultant and equilibrant forces in this situation.

Solution

Kipute is correct.

Explanation:

When she sits at rest: Weight (W) acts downward. Normal reaction (R_n) from the chair acts upward. These two forces are equal in magnitude and opposite in direction, so the resultant force is zero. This means there is no acceleration and the system is in equilibrium. Kipanga's idea is incorrect because equilibrium does not require a stronger force but only equal and opposite forces.

Clarification:

The upward reaction from the chair acts as the equilibrant force to her weight. It balances the downward gravitational force that would otherwise cause downward acceleration.

Making Sense of the Answer: *Objects at rest are not force-free. Usually, forces are present but balanced. Sitting comfortably is actually a perfect demonstration of equilibrium though it may not feel like Physics at the time.*

Thinking Like a Physicist: *Whenever you see something stationary, ask:*

- *What forces are acting?*
- *Which ones balance each other?*

Having given the worked examples their full say, we can now welcome the next subtopic and see what fresh ideas it brings along.