COMMUNITY GALLERY Drone Simulation

## Drone Simulation

**Learning Outcome(s)**

Subject and Level

| Subject | Level |
|---|---|
| Physics | Secondary 3 Express |
| Physics | Secondary 4 |
| Science | Secondary 3 |
| Science | Secondary 3 |
| Science – Physics | Secondary 4 |
| Science – Physics | Secondary 4 Normal (A) |

Content Map and Topic

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- apply Newton's Laws to:
(i) describe the effect of balanced and unbalanced forces on a body
(ii) describe the ways in which a force may change the motion of a body
(iii) identify action-reaction pairs acting on two interacting bodies
(stating of Newton's Laws is not required)
- recall and apply the relationship *resultant force* = *mass* × *acceleration* to new situations or to solve related problems
- show an understanding that there are energy stores, e.g. kinetic, potential (gravitational, chemical, elastic), nuclear and internal, and that energy can be transferred from one store to another:
(i) Mechanically (by a force acting over a distance)
(ii) Electrically (by an electric current)
(iii) By heating (due to a temperature difference)
(iv) By propagation of waves (both electromagnetic and mechanical)

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# Newton’s First Law — Drone Hover Challenge

Newton’s First Law of Motion

### Learning Objectives

By the end of this activity, students should be able to:

1. Describe Newton’s First Law of Motion.
2. Explain balanced and unbalanced forces.
3. Predict drone motion when thrust changes.
4. Explain stable hovering using force balance.
5. Relate resultant force to acceleration and motion.

In this activity of simulation

- students actively control forces,
- overshooting naturally demonstrates inertia,
- and hovering requires conceptual understanding rather than memorization.

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## A. Drone Hover Challenge

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**1. Newton's First Law — Drone Hover Challenge**

# Introduction

Newton's First Law states:
An object remains at rest, or continues moving at constant velocity, unless acted upon by an unbalanced force.

In this drone simulation:

- ⬆️ thrust acts upward
- ⬇️ weight acts downward

The drone's motion depends on the balance between these forces.

# Force Conditions

**Thrust > Weight**

- Resultant force acts upward.
- Drone accelerates upward.

**Thrust = Weight**

- Forces are balanced.
- Resultant force is zero.
- Drone can hover or move at constant speed.

**Thrust < Weight**

- Resultant force acts downward.
- Drone accelerates downward.

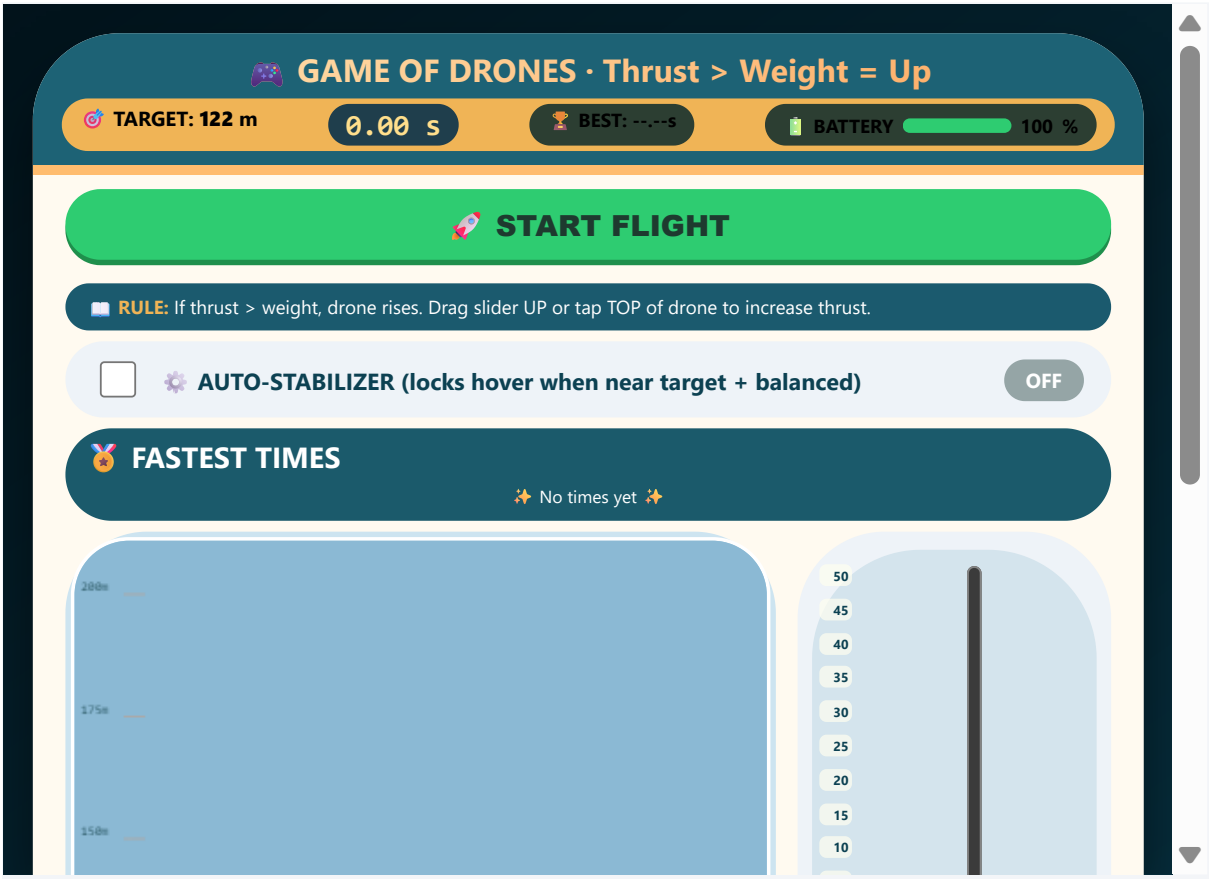
# Mission Instructions

**Mission**

Control the drone and achieve a stable hover at the target altitude.

**Controls**

- Drag slider UP → increase thrust
- Drag slider DOWN → decrease thrust
- Tap TOP of drone → increase thrust
- Tap BOTTOM of drone → decrease thrust

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## 2. Investigation Questions / Reflection

### Q1:

A drone has a mass of 2.5 kg. On Earth, the gravitational field strength is 10 N/kg. What is the weight of the drone?

- 2.5 N
- 10 N
- 25 N
- 250 N

MARKS: / 1

### Q2:

If the upward thrust force from the drone's propellers is greater than the weight of the drone, what will happen to the drone?

- It will move upward.
- It will stay at the same height.
- It will move downward.
- It will spin around.

MARKS: / 1

### Q3:

A drone has a thrust of 30 N upward and a weight of 22 N downward. What is the direction of the net (resultant) force acting on the drone?

- Upward
- Downward
- Zero
- Sideways

MARKS: / 1

**Q4:**

If the upward thrust force is less than the weight of the drone, what will happen to the drone?

- It will rise upward.
- It will hover in place.
- It will descend downward.
- It will move sideways.

MARKS: / 1

**Q5:**

The net (resultant) force on a drone is zero. The drone is moving upward at a constant speed of 2 m/s. What will happen to the drone?

- It will keep rising at 2 m/s.
- It will stop immediately.
- It will fall downward.
- It will speed up.

MARKS: / 1

**Q6:**

What is the correct unit for weight (the force of gravity on an object)?

- Kilogram (kg)
- Newton (N)
- Metre per second (m/s)
- Joule (J)

MARKS: / 1

**Q7:**

For a drone to hover perfectly at a fixed height, which two conditions must be true at the same time?

- Thrust must be greater than weight and speed must be zero.
- Thrust must be less than weight and speed must be zero.
- Thrust must equal weight and speed must be zero.
- Thrust must equal weight and the drone must be moving fast.

MARKS: / 1

**Q8:**

Before the drone takes off, its battery contains a store of energy. What is the name of this energy store?

- Kinetic energy store
- Gravitational potential energy store
- Chemical energy store
- Thermal energy store

MARKS: / 1

**Q9:**

As the drone rises upward to a higher altitude, which energy store increases?

- Kinetic energy store
- Gravitational potential energy store
- Chemical energy store
- Elastic potential energy store

MARKS: / 1

**Q10:**

When the drone is hovering at a constant height, what is happening to its gravitational potential energy store?

- It is increasing.

- It is decreasing.
- It is staying constant.
- It is being destroyed.

MARKS: / 1

**Q11:**

As the drone's battery drains and becomes very low, what happens to the maximum thrust the drone can produce?

- The maximum thrust increases.
- The maximum thrust stays the same.
- The maximum thrust decreases.
- The drone becomes lighter.

MARKS: / 1

**Q12:**

The Auto-Stabilizer in the game helps the drone hover. Which three conditions must all be true at the same time for the Auto-Stabilizer to activate and lock the drone at the target height?

- Near target, thrust greater than weight, slow speed
- Near target, thrust less than weight, sudden reversal
- Near target, thrust balanced, sudden direction reversal
- Far from target, thrust balanced, slow speed

MARKS: / 1

**Q13:**

In the Game of Drones simulation, you learned that hovering requires both balanced forces (thrust = weight) AND zero speed. Describe a real-world situation where understanding this physics principle is important. Explain why simply making forces equal is not enough to stop an object that is already moving.

**Feedback**

MARKS: / 1

**Q14:**

In the Game of Drones simulation, the drone's battery contains a chemical energy store. As the drone flies, energy is transferred from the chemical store to other energy stores. Describe the main energy transfers that occur when the drone takes off, rises to a higher altitude, and then hovers. In your answer, name the energy stores involved and explain why the drone does not continue rising forever even if thrust equals weight.

**Feedback**

MARKS: / 1

**Q15:**

What difficulties did you face when trying to hover the drone at the target altitude? Describe at least two problems you encountered and explain how you overcame them using your understanding of forces and motion.

**Feedback**

MARKS: / 1

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### 3. Guide to Hovering Faster

## Guide to Hovering Faster

**Important TASK :**

- specific instructions provided below for improvement.
- replay the simulation with focused goals. only after you have understood.

**The Core Physics Law**

**Newton's Second Law: Force equals mass times acceleration.**

For the drone: Net force = Thrust upward − Weight downward − Drag.

- If net force is upward, the drone speeds up going up.
- If net force is downward, the drone speeds up going down.
- If net force is zero, the drone keeps its current speed (Newton's First Law).

To hover perfectly, you need two things: net force must be zero AND speed must be zero.

## What Is Drag

Drag is the force of air pushing against the drone's motion. It always opposes movement.

When the drone rises, drag pulls downward. When the drone falls, drag pulls upward. The faster the drone moves, the stronger the drag. In this game, drag equals 1.2 multiplied by the drone's speed.

Drag acts as a natural brake. It helps slow the drone down without using extra thrust or battery.

## Why Sudden Direction Reversal Alone Does Not Stop the Drone

Many players think flicking the slider stops the drone. This is not correct.

Sudden direction reversal only tells the game "the pilot wants to change direction." It does nothing by itself.

The drone keeps moving because of inertia. Newton's First Law says an object in motion stays in motion unless a net force acts on it. A reversal changes the direction of the net force, but the drone still has speed and will keep moving.

To actually stop, three conditions must happen together with the Auto-Stabilizer turned on.

## The Three Conditions for Instant Stop

**Condition One: Near target.**
The drone must be within 1.5 metres of the red target line. This ensures you are close enough to lock the hover.

**Condition Two: Thrust balanced.**
Thrust must be almost exactly equal to weight, within 0.6 Newtons. The red marker on the slider shows your weight. When the red "THRUST = WEIGHT" message appears, you are balanced. At this point, the net force from thrust and weight is zero.

**Condition Three: Sudden direction reversal.**
You must quickly drag the slider past the red line. A fast flick creates a large, clear change in the direction of net force. A slow drag may not be detected.

When all three conditions are true at the same time and Auto-Stabilizer is ON, the game instantly sets speed to zero and locks thrust equal to weight. The drone stops immediately and hovers perfectly.

## How to Hover Faster Using Physics

**Strategy One: Accelerate hard, then coast.**

Use thrust 5 to 10 Newtons above weight to rise quickly. A large thrust difference creates large net force, which creates large acceleration. This gets you to the target faster. When you are 3 to 5 metres below the target, drop thrust to exactly match weight. From this point, net force from thrust and weight is zero. Only drag acts on the drone. Drag slows you down naturally. You will reach the target with near-zero speed, avoiding overshoot.

**Strategy Two: Balance thrust precisely before flicking.**

Use the red marker as your weight reference. Adjust the slider slowly until the red "THRUST = WEIGHT" message appears. This is the equilibrium point. From equilibrium, any change creates a clear net force in one direction. The stabilizer detects this clean signal and triggers. If thrust is not balanced, the net force is already non-zero, and the reversal signal is mixed. The stabilizer may not activate.

**Strategy Three: Flick fast, not slow.**

The game detects sudden reversal by checking whether the direction of thrust relative to weight changed in the last half second. A fast flick creates a large rate of change. This crosses the detection threshold clearly. A slow drag may not change direction fast enough, so the game does not register a reversal and the stabilizer does not trigger.

## The Physics of Drag as Your Brake

Drag equals 1.2 multiplied by speed.

When rising at 5 metres per second, drag equals 6 Newtons downward. When falling at 3 metres per second, drag equals 3.6 Newtons upward.

Because drag always opposes motion, it naturally slows the drone down. You do not need to perfectly time your thrust reduction. Simply set thrust equal to weight and let drag do the braking. This saves battery and makes hovering much easier.

## Common Mistakes and Why They Happen

**Overshooting the target** happens because you keep thrust high for too long. Large net force keeps accelerating you upward. Once you are moving fast, you need equal net force downward to stop. That takes extra time. The fix is to reduce thrust early, about 3 to 5 metres below target, and let drag slow you down naturally.

**Oscillating up and down** happens because you cannot find the exact balance point. You go from too much thrust to too little thrust, back and forth. The fix is to use the red marker and the "THRUST = WEIGHT" message as your guide. Stop chasing. Find the exact point and hold it.

**Stabilizer not triggering** happens because you did not meet all three conditions or you moved the slider too slowly. The fix is to check your distance to target, check that thrust is balanced, then flick the slider fast, not slow.

## The Fastest Flight Profile Step by Step

Start the flight with the drone on the ground. Push the slider up hard to create a large thrust-weight difference. The drone accelerates upward quickly. Watch the altitude display. When you are about 5 metres below the target altitude, reduce thrust to exactly match weight. Use the red marker as your guide. Now the net force from thrust and weight is zero. Only drag acts on the drone. Drag slows you down gradually. You will reach the target height with speed close to zero. At this moment, you are near target and thrust is balanced. Flick the slider fast past the red line. The game detects the sudden reversal. The Auto-Stabilizer triggers and instantly sets speed to zero. The drone locks perfectly at the target height. Your certificate appears.

## One Sentence Summary

Use a large thrust difference for fast ascent, let drag slow you to zero speed, balance thrust exactly at the red marker, then flick the slider fast — the stabilizer will lock your hover instantly.

**4. HOW TO HOVER FASTER (Simple Version)**

# HOW TO HOVER FASTER (Simple Version)

### The Main Rule to Remember

- **Push up harder than weight** → drone goes up
- **Push up less than weight** → drone goes down
- **Push up exactly equal to weight AND speed is zero** → drone stays still (hovers)

### Three Simple Tricks

**1. Go up fast, then let go gently**
Use strong thrust to rise quickly. When you are a little below the target, reduce thrust to exactly match weight. The air pushing against the drone (drag) will slow you down naturally. You will stop right at the target without overshooting.
**2. Get thrust exactly equal to weight before you flick**
The red marker on the slider shows your drone's weight. Move the slider until the red message says "THRUST = WEIGHT". Now you are ready.
**3. Flick the slider fast, not slow**
A quick, sharp flick past the red line tells the game "I want to stop now". A slow drag might not work. Fast flick = instant hover lock.

### What Slows You Down (Avoid These)

- **Pushing too hard for too long** → you shoot past the target and have to come back down. Wastes time.
- **Moving the slider too slowly when trying to trigger the stabiliser** → the game does not recognise it as a "sudden change". No hover lock.
- **Low battery** (below 20%) → your max thrust gets cut in half. Takes much longer to rise.

### The Fastest Way to Hover (Step by Step)

1. **Start flight** – drone on ground
2. **Push slider up hard** – drone rises fast
3. **When near target (orange line)** – drop thrust to exactly match weight (red marker level)
4. **Let air resistance slow you down** – you will stop right at the target
5. **Flick the slider fast past the red line** – stabiliser locks the hover
6. **Certificate appears** – mission complete!

### One Easy Sentence

*Push hard to go up fast, then balance thrust with weight, let the air slow you down, and flick the slider quickly — the game will lock your hover instantly.*

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### 5. Teacher's Guide

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