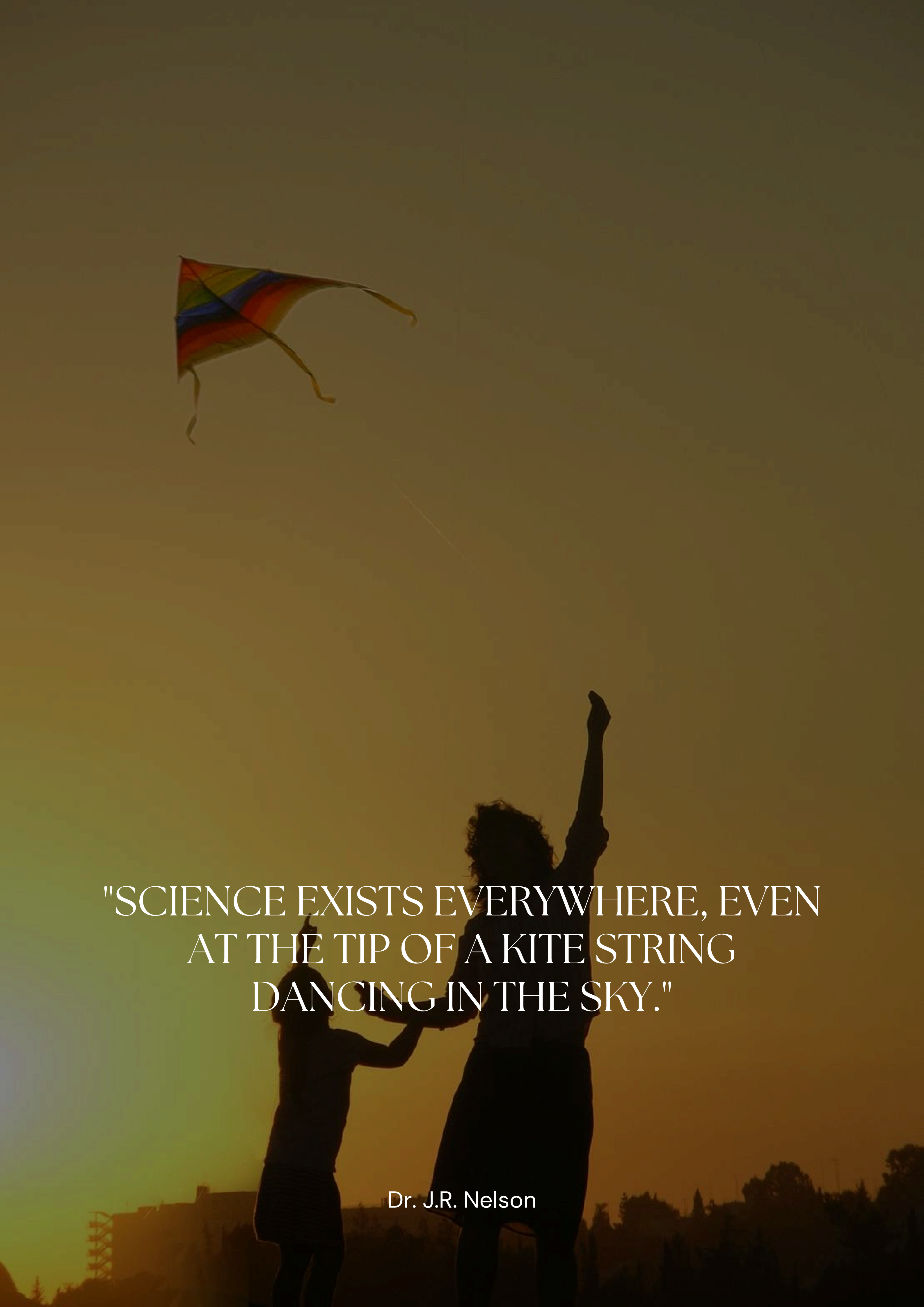
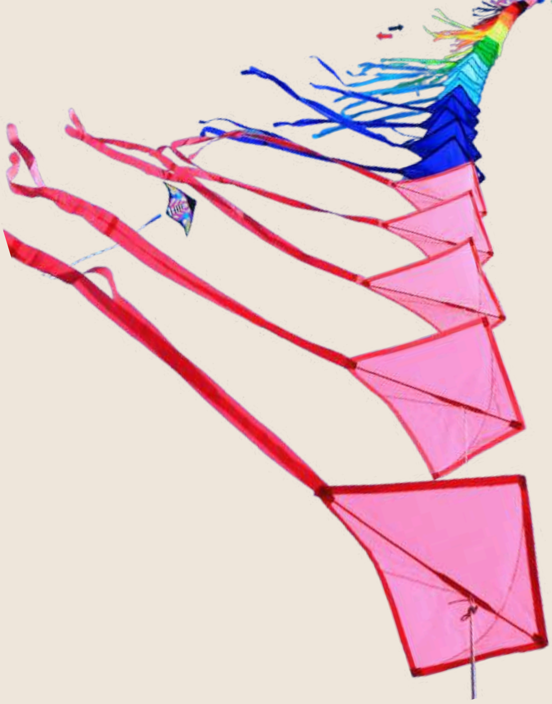
HAFIS DRI SAYOGA

TRADITIONAL KITES

EXPLORING CULTURE AND AERODYNAMICS SCIENCE FROM THE ARCHIPELAGO TO THE WORLD


"SCIENCE EXISTS EVERYWHERE, EVEN AT THE TIP OF A KITE STRING DANCING IN THE SKY."
Dr. J.R. Nelson



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INTRODUCTION

Kites as a Bridge of Culture and Science

KITES AS A BRIDGE OF CULTURE AND SCIENCE

Kites are not just a childhood game, but are a symbol of culture, artistic expression, and scientific objects that have crossed time and space. In different parts of the world, kites play an important role in the traditions and lives of people. In Indonesia, kites such as Janggan in Bali and kite fighting in West Java are not only entertainment, but also part of rituals and festivals that are full of spiritual and social meaning. In Malaysia, the crescent-shaped Wau Bulan with floral decorations has become a national icon symbolizing the beauty and heritage of Malay culture. The tradition of flying Wau is preserved through festivals and competitions, particularly in the states of Kelantan and Terengganu, which attract foreign tourists.

Globally, kites have been used for a variety of purposes, from military communication tools in ancient China to scientific experiments by Benjamin Franklin in the United States. In Japan, Tako kites are painted with the faces of gods or warriors as part of religious ceremonies. India celebrates the festival of Makar Sankranti with a sky full of thousands of colorful kites. Even in the United States, kites were used by Benjamin Franklin in his famous electrical experiments. These traditions show that kites are not only flying objects, but also a medium that connects humans to nature, culture, and science.

In the context of education, kites offer a unique opportunity to integrate STEM (Science, Technology, Engineering, and Mathematics) concepts with local wisdom. Through kite making and flight, students can understand the principles of aerodynamics, such as lift and angle of attack, as well as develop technical and creative skills. Thus, kites become a bridge between tradition and innovation, between the past and the future.

02

HISTORY

and Variety of Kite Culture

2.1 TRACES OF THE HISTORY OF KITES IN THE WORLD

Kites have a long history that spans more than two millennia. Thought to have originated in China around the 5th century BC, early kites were made of bamboo and silk, used by the military to measure distance, send messages, and even test the wind before an attack. In the historical records of the Han Dynasty, there is a story about General Han Xin using a kite to estimate the length of a secret tunnel leading to an enemy fortress.

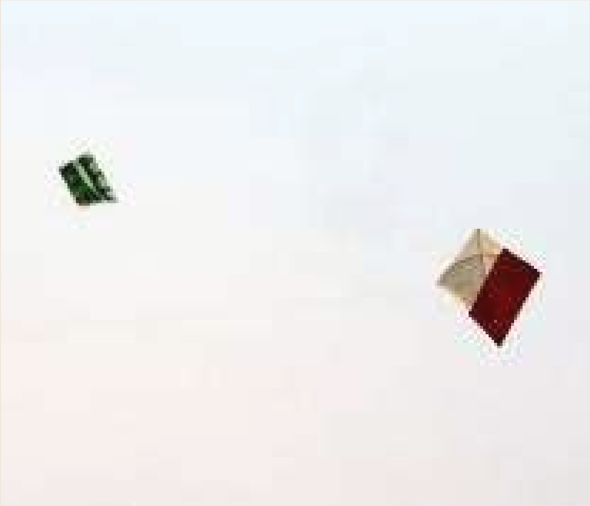
The technology and art of kites spread to Japan, Korea, India, and the Islamic world, then to Europe via the Silk Road. In various places, it adapts to the local culture and becomes part of religious ceremonies, harvest celebrations, to symbols of peace and exorcisms.

2.2 KITE TRADITION IN INDONESIA

In Indonesia, cultural diversity is reflected in the different forms and functions of kites in each region:

- Bali has a janggan kite, known for its very long tail up to tens of meters. This kite is used in the Bali Kite Festival as part of an offering to Lord Vishnu to maintain the balance of nature.

- West Java has a battle kite or war kite, which is small and agile, made to compete to break the opponent's thread in the air.



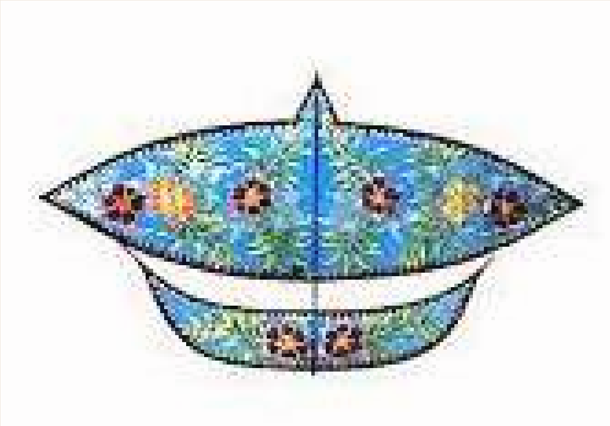
- South Kalimantan knows Bahambangan Layang, a traditional Banjar tradition to welcome the planting or harvest season.

2.3 WAU: MALAYSIAN CULTURAL PRIDE

In Malaysia, Wau is not just a game, but a cultural heritage full of philosophy. The name "Wau" comes from the "wow" sound produced when a kite flies and vibrates in the air. The three most popular types of wau are:

- Wau Bulan: shaped like a crescent moon, it is a symbol of national culture and part of the logo of Malaysia Airlines.

- Wau Kucing : resembles the shape of a cat, with a distinctive geometric pattern.



- Wau Barat: kites from the west coast region of Malaysia with artistic designs.

The states of Kelantan and Terengganu actively preserve wau culture through an annual international festival, where wau artisans compete to showcase their best work. The process of making wau involves high precision, from bamboo selection, cutting techniques, to painting patterns by hand.

2.4 KITE CULTURE IN OTHER COUNTRIES

China

As the origin of kites, the country has various symbolic forms such as dragons, phoenixes, and humans. The Weifang Kite Festival in Shandong Province is one of the largest kite events in the world.

Japan

Known as Tako, which is often used in New Year celebrations and children's festivals. The designs often feature the faces of samurai, Shinto gods, or mythological figures.

India

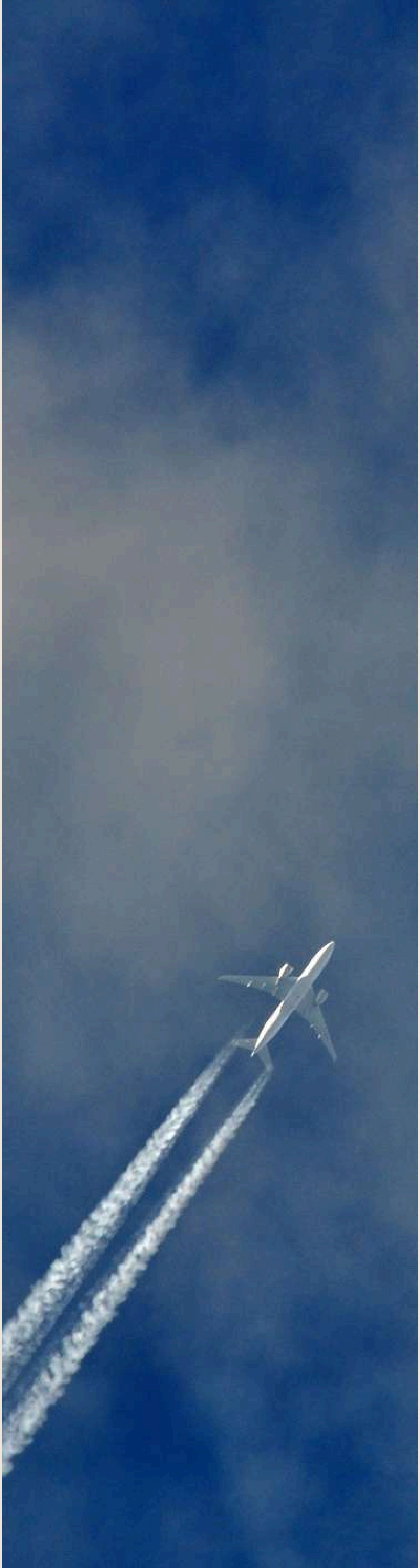
The Makar Sankranti festival in Gujarat is celebrated with thousands of colorful kites adorning the sky, a symbol of the triumph of light over darkness.

Thailand

Has a traditional game between two types of kites, Chula (large) and Pakpao (small), which are played competitively in teams.

Brazil and **Chile**

Flying kites as part of street culture, with local variations such as pipes and comets also used in complaints.



03

THE PHYSICS

Behind the Kite

3.1 PRINCIPLES OF AERODYNAMICS: LIFT AND THRUST

Kites are a perfect example of the application of aerodynamic principles in everyday life. The main principle that allows a kite to fly is the lifting force, which is generated by the difference in pressure between the top and bottom of the kite. This is directly related to the theory of airflow.

- Lift: The kite is lifted into the air due to the pressure difference caused by the air flow around the kite's surface. When air flows faster over the surface of the kite than below it, the pressure above will be lower than below, creating lift.
- Thrust: In addition to lifting, kites also need thrust to keep their movements forward. This force can be generated by the wind blowing against the surface of the kite or the movement of the yarn attached to the kite.

3.2 ANGLE OF ATTACK AND WIND SPEED

The success of the kite to keep flying is also greatly influenced by the angle of attack. The angle of attack is the angle between the direction of the airflow and the horizontal line of the kite.

- Angle of Attack: When the kite is positioned with an optimal angle of attack, the resulting lift will be maximized. If the angle of attack is too small or too large, the lift formed will be reduced, and the kite will be difficult to fly or even fall.
- Wind Speed: Wind speed greatly affects a kite's ability to fly. Stronger winds will generate more thrust and lift, while weak winds will make it difficult for the kite to stay flying. Therefore, kite players often choose the right time and place, where the wind speed is suitable for the kite to be flown in.

3.3 GRAVITATIONAL FORCE AND INHIBITION FORCE

In addition to lift and thrust, there are two other forces that act on kites in flight:

- Gravitational Force (Weight): This force works downwards and is the force that the lift must resist in order for the kite to fly. The weight of a kite depends on the material used to make it, which also affects the lift and stability of the flight.
- Drag: Drag is a force that acts opposite to the direction of the kite's motion. This is caused by the friction of air with the surface of the kite. The more aerodynamic the shape of the kite, the smaller the drag it receives, and the easier it will be for the kite to fly stable.

3.4 KITE STABILITY

The stability of a kite is one of the important aspects of its flight. A stable kite will fly in a fixed direction and will not be easily swayed by the wind.

- Shape and Design: The shape of a kite affects its aerodynamics and stability. Kites with long tails, such as traditional Balinese kites (Janggan), are more stable because the tail functions to add a drag force at the back, which helps control the movement of the kite in the air.
- Thread Mounting System: The strength and position of the thread also affect the stability of the kite. When the yarn is pulled too hard or at the wrong angle, the kite can become unstable. Therefore, the kite controller needs to adjust the strength and direction of thread pull to maintain flight stability.

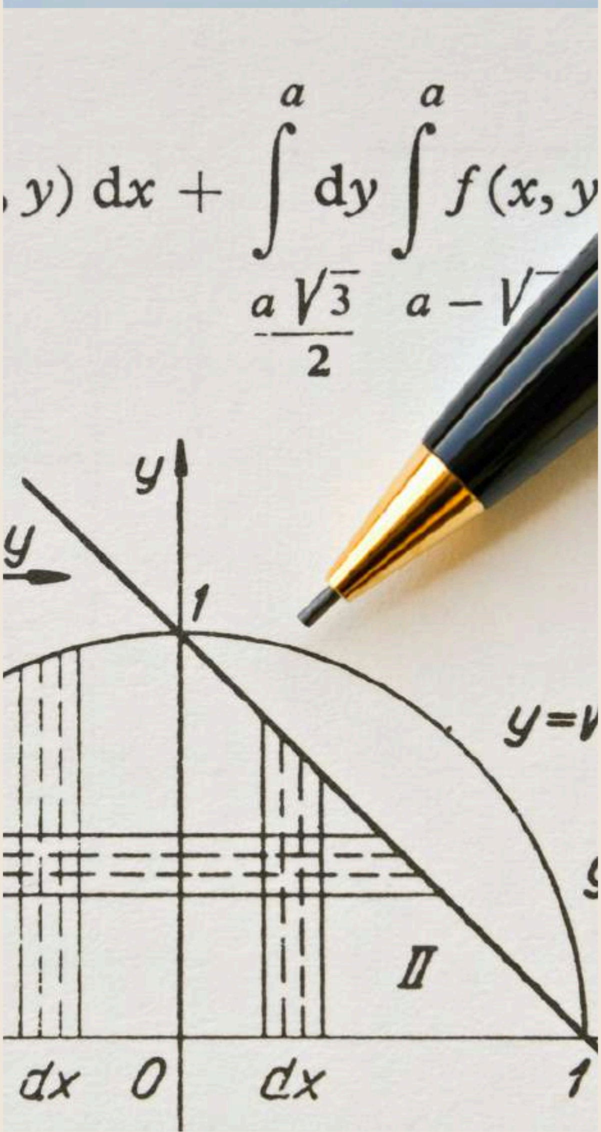
3.5 EXPERIMENTS AND SCIENTIFIC DISCOVERIES WITH KITES

In addition to being a game and cultural object, kites also serve as a tool for scientific experiments. One of the famous experiments using kites was the one conducted by Benjamin Franklin in 1752, which used kites to prove that lightning is a form of electricity.

Franklin flew a kite in the rain to observe the relationship between lightning and electricity. He discovered that kites carried into the sky during storms could attract lightning, leading to the discovery of the basic principles of static electricity and electrical conductivity.

3.6 OTHER SCIENTIFIC APPLICATIONS

- Wind Energy: Like flying kites, kite energy technology or kite-based wind energy began to be developed to generate electricity. The technology uses large kites that fly at altitude to take advantage of higher wind speeds, which are then converted into electrical energy.
- Wind Measurement: Kites are also used to measure the direction and speed of the wind at different altitudes. This is especially important in meteorology and aviation.



04

SIMPLE MATH SIMULATION

Can My Kite Fly

4.1 UNDERSTANDING BALANCE OF FORCES IN KITE FLIGHT

To understand how a kite can fly stably, we need to pay attention to the balance between several forces acting on it. One of the best ways to calculate it is to use simple physics formulas that relate lift, weight, and other factors. In this section, we'll use math to determine if our kite can fly with the available wind.
Simulation Steps:

Calculating Lift (Lift)
As discussed earlier, the lift force (FLF_LFL) on a kite can be calculated using the following formula:

$$F_L = \frac{1}{2} \cdot \rho \cdot v^2 \cdot A \cdot C_L$$

Where:
ρ : density of air (usually 1,225 kg/m³ at 15°C),
v^2 : wind speed relative to the kite (in m/s),
A : kite surface area (in m²),
C_L :coefficient of lifting force, which depends on the shape of the kite and its angle of attack.

For example, we have a delta-shaped kite with a surface area of 0.5 m², a wind speed of 5 m/s, and an elevator coefficient C_L= 0.8.

Then the lifting force can be calculated as:

$$F_L = \frac{1}{2} \cdot 1.225 \cdot 52 \cdot 0.5 \cdot 0.8 \approx 6.13N$$

Calculating WeightGravity
Is the gravitational force that pulls the kite down. This is calculated by the formula:

$$W = m \cdot g$$

Where:
- m : kite mass (in kg),
- g : gravitational acceleration (9.8 m/s²).

Suppose the float is 0.4 kg, then the weight force is: $W = 0.4 \cdot 9.8 = 3.92N$

Analyzing the Balance of ForceIn order for a kite to fly stably, the lifting force (F_L) must be greater than the weight force (W). In this simulation, we have:
- Lifting force: 6.13 N
- Weight: 3.92 N

Since the lift force is greater than the weight, the kite will fly. However, its stability also depends on other factors, such as the drag force and the pull force of the rope that regulates the direction of flight.

4.2 ADDING STABILITY FACTOR WITH DRAG

An impediment force is an obstacle provided by air to the movement of a kite. To estimate the drag force, we can use a simple formula for drag:

$$F_D = \frac{1}{2} \cdot \rho \cdot v^2 \cdot A \cdot C_D$$

Where:

- F_D : Resistance Force,
- C_D : The drag coefficient, which is usually between 0.1 to 1.0 for kites, depending on the design and the smoothness of the surface.

For example, for our kite that has , the drag force is: C_D = 0.4.

$F_D = \frac{1}{2} \cdot 1.225 \cdot 52 \cdot 0.5 \cdot 0.4 \approx 3.06N$

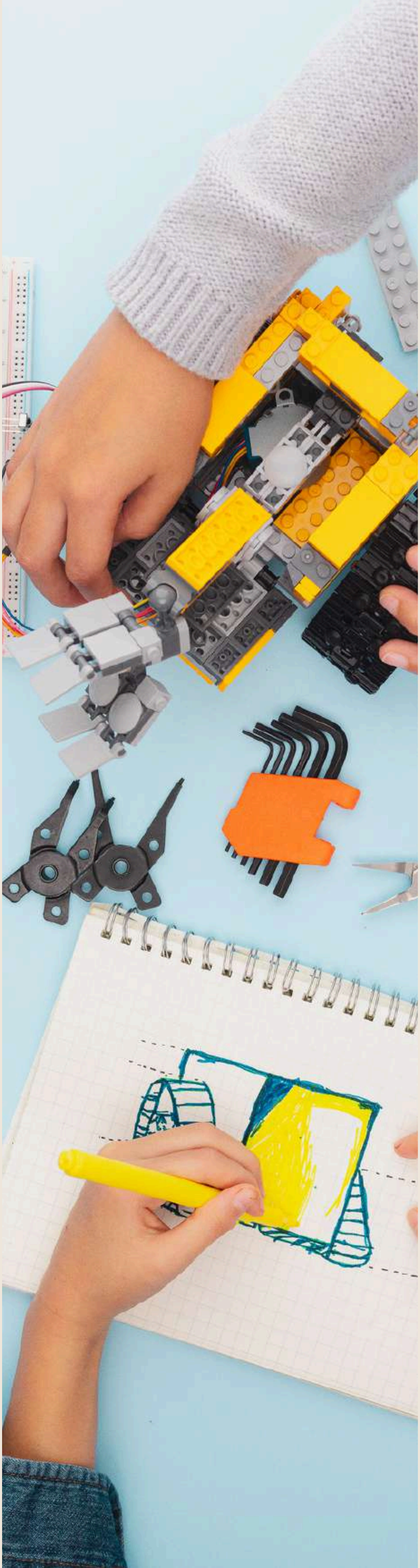
This drag force will reduce the speed of the kite's movement and affect its stability, especially if the wind is blowing with varying forces.

4.3 SUMMING UP THE MATHEMATICAL SIMULATION

Based on the above calculations, we can draw several conclusions:

- The lifting force of the kite (6.13 N) is greater than its weight force (3.92 N), which means that the kite will be lifted into the air.
- The drag force (3.06 N) affects the speed and stability of the flight, but it is not large enough to stop the flight.
- The pulling force of the rope set by the player will ensure that the kite remains stable and controllable, although the wind may vary.

Thus, these kites can fly well in selected wind conditions, and their stability is highly dependent on the shape of the kite and the skills of the controller.



05

CREATIVITY AND INNOVATION

Making Kites as a STEM Project

Kites, although they look simple, are a real example of how science, technology, engineering, and mathematics (STEM) can be applied in everyday life. Building kites is not just a matter of drawing patterns or choosing materials, but it also involves physics and mathematical experiments to create an optimal design. In STEM projects, kite making can be a means to teach scientific concepts in a practical way.

5.1 SCIENCE: EXPERIMENTS ON THE INFLUENCE OF FORM AND MATERIAL ON LIFTING

Kite making as a scientific experiment involves understanding how shape and material affect lift. In this context, students can try to create different types of kites with different shapes, such as delta kites, box kites, or animal-shaped kites, to test how well they can fly. This experiment helps students understand aerodynamic phenomena firsthand.

Experimental steps:

1. Materials used: Choose several different types of materials, such as plastic, paper, light fabric, and bamboo for the kite frame.
2. Kite shape: Design several different kite shapes, such as delta kites, animal-shaped kites, or geometric kites.
3. Test: Fly the kite in a place with a stable wind and measure its altitude and stability. Take note of the results and observe which factors affect the fly's flight, such as lighter materials, more aerodynamic shapes, or better angles of attack.

From these experiments, students can learn about the relationship between kite design and their flight performance, as well as the ways physics works in real life.

5.2 TECHNOLOGY: USE OF SENSORS AND MICROCONTROLLERS FOR MEASUREMENT

To take kite making to a higher level, technology can be used to collect data about kite flight in real-time. For example, using sensors to measure the altitude, wind speed, or even the position of the kite in the air. Microcontrollers such as Arduino or ESP32 can be programmed to collect data from sensors and transmit it to other devices such as smartphones or computers.

Examples of technology use:

1. Altitude sensor: Attach an altimeter sensor to the kite to measure its altitude while flying.
2. Wind speed sensor: Use an anemometer to measure the wind speed affecting the kite.
3. Microcontroller: Use the ESP32 to connect the sensor with the app that displays the data in real-time.

Through this project, students learn not only about kite flight but also how technology can be used to collect and analyze data.

5.3 ENGINEERING: DESIGNING EFFICIENT AND DURABLE KITES

In the engineering aspect, students can design kites that are more efficient and durable by paying attention to materials, structure, and weight distribution. This process teaches about the strength of materials, load distribution, and the importance of structural design in creating objects that can withstand a variety of conditions, including strong winds.

Kite design project:

1. Material selection: Determine the most suitable material for the kite frame (such as bamboo or fiberglass) and the covering material (such as plastic or fabric).
2. Structure design: Create a kite design with attention to a balanced weight distribution and the use of lightweight but strong materials.
3. Prototyping: Build kites from pre-made designs and test their resistance to weather conditions, such as strong winds or light rain.

By designing and building kites, students learn about the technical aspects of engineering and the application of the principles of physics they learned earlier.

5.4 MATHEMATICS: CALCULATING THE OPTIMAL FORCE, AREA, ANGLE, AND SPEED

Math is key to calculating many important aspects of kite design, from the surface area to the optimal angle of attack to produce maximum lift. Students can be taught to calculate various parameters that will affect kite flight, such as wind speed, the force acting on the kite, and the optimization of kite shape.

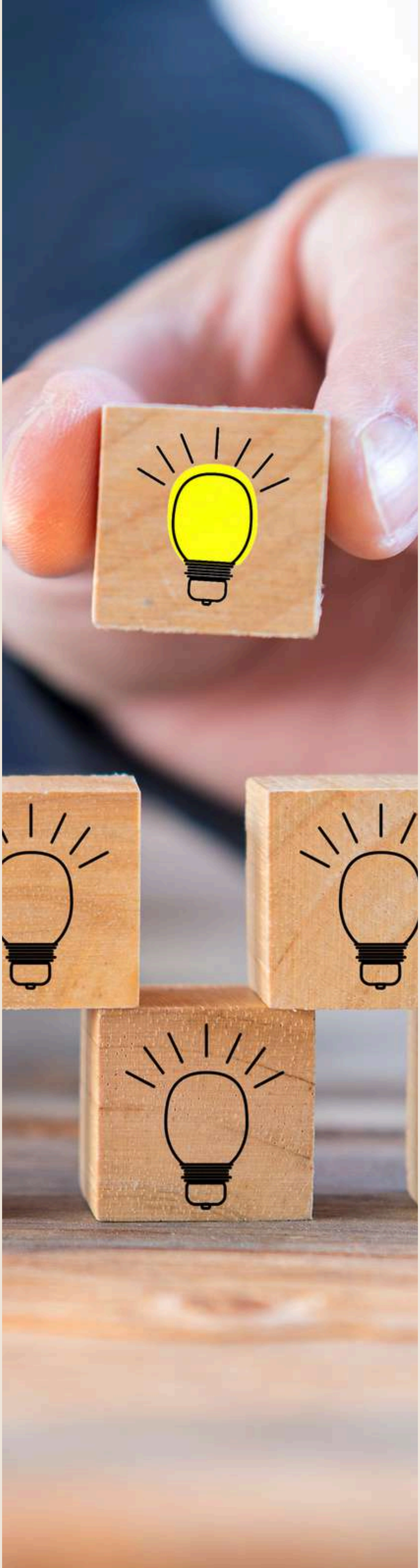
Steps of mathematical calculation:

1. Calculating the surface area of the kite: Determine the size and shape of the kite, then calculate the surface area to determine the lift force produced.
2. Calculating the angle of attack: Determine the optimal angle of attack to ensure maximum lift.
3. Calculating the working force: Use the formulas of lift, drag force, and rope pull force to calculate the balance of force on the kite.

Through these calculations, students can understand how mathematics is used to predict and analyze kite flight more precisely.

5.5 SUMMING UP THE KITE STEM PROJECT

Kite making as a STEM project allows students to develop skills in science, technology, engineering, and math hands-on. With practical experiments, the use of modern technology, structural design, and mathematical calculations, students not only learn scientific concepts and techniques, but also how to apply them in daily life. The project also encourages creativity, collaboration, and problem-solving, all of which are essential skills in the STEM world.



06

CONCLUSION

Bringing Heaven, Culture, and Science Together

Kites are more than just objects that fly in the air. It is a symbol that connects culture, art, and science, bringing together various disciplines in one beautiful and useful unit. From the traditions of the people of the archipelago, Malaysia, to the rest of the world, kites are present as a means of cultural expression that is not only entertaining, but also teaches profound principles of physics and mathematics.

We have seen how kites play an important role in the cultures of different countries. Every shape of kite, whether it's the wau bulan in Malaysia, the Janggan kite in Bali, or the traditional Chinese kite, reflects the values and stories of the people who created it. However, more than that, kites are a field of scientific experimentation that introduces basic concepts of physics, such as lift, drag, and rope pull.

Behind their simplicity, kites hold tremendous learning potential for the younger generation, especially in the context of STEM (science, technology, engineering, and mathematics). The manufacture and flight of kites can be a practical project that brings together science and technical skills. These kinds of projects not only teach students about the principles of physics, but also stimulate their creativity in designing efficient and stable flying objects.

Kites teach us to combine local culture with modern science, enriching our understanding of the universe. Through STEM projects involving kite making, students not only learn about the theory behind flight, but also understand that science and culture can go hand in hand. Just like kites flying freely in space, an understanding of science, technology, engineering, and mathematics can also "fly high" through creative and innovative approaches.

The application of STEM in kite making also involves collaboration between disciplines. Physics, mathematics, technology, and engineering are combined in one in-depth and thorough project. This collaboration is not only important in the world of education, but it is also relevant in future professional life, which requires cross-disciplinary skills.

Through the STEM approach, students can experience firsthand how science and technology can enrich our cultural heritage. In this sense, the kite is not only a cultural symbol, but also a bridge that connects us with the world of science and technology. Therefore, the further development of kites as learning objects will enrich our understanding of the world we live in and how we can innovate in the future.

GLOSSARY

Aerodynamics: A branch of physics that studies the behavior of fluids (air) and their interactions with the surface of moving objects.

Angle of Attack: The angle between the direction of the airflow and the base line of the kite that affects the magnitude of the lift.

Drag: The force opposite to the motion produced by the friction between the water and the surface of the kite.

Drag Coefficient: A number that shows the air resistance a surface receives.

Elevation Angle: The angle between the horizontal and the line of sight to the kite; affects the lift and rope pull components.

Lift: The upward force generated by the difference in pressure around the surface of the kite.

Lift Coefficient: A number that shows the efficiency of a surface in generating lift.

Lift-to-Drag Ratio: A ratio between lift and drag that describes aerodynamic efficiency.

Rope Pull Force (Tension): The force transmitted through the rope that connects the kite and the player, which controls height and stability.

Momentum: The quantity of motion equal to mass multiplied by velocity.

Weight: The gravitational pull that pulls the kite toward the earth, calculated as the mass of the kite multiplied by the acceleration of gravity.

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