**MATH – ACT Alignment: Measurement, Trigonometry & Data Analysis**

The **ACT-aligned Math** component of the Build Your Own Catapult kit focuses on applying measurement, trigonometry, and data analysis to real-world physics. Students use the metric system and precise measurement tools to calculate launch angles, distances, and projectile trajectories. By incorporating the Pythagorean theorem and trigonometric functions like sine, cosine, and tangent, they analyze the relationships between angle, force, and motion. Additionally, statistical methods help students assess accuracy and efficiency, reinforcing problem-solving skills essential for engineering and applied mathematics.

🔹 **ACT Math Rating Scale – Applied Mathematics & Geometry**
• (16-19) Understanding basic measurements and angles.
• (20-23) Applying algebraic equations to projectile motion.
• (24-27) Using trigonometric functions to calculate launch distance.
• (28-32) Advanced mathematical modeling of catapult trajectories.
• (33-36) High-level calculations of force, velocity, and energy efficiency.

**📌 Activity 1: Measuring Launch Angles & Distances**

**Objective:** Students use trigonometry to calculate launch angles and distances.

**Materials Needed:** Ruler, protractor, meter stick, catapult, target board, calculator.
**Student Task:**

1. Adjust the catapult to three different launch angles (30°, 45°, 60°).
2. Measure and record the distance each projectile travels.
3. Use the sine and cosine functions to calculate the expected vs. actual distance.
4. **Discuss:** Why does 45° typically produce the farthest distance?

**ACT Question Example:**
A student launches a projectile at a 60° angle with an initial velocity of 10 m/s. What is the horizontal distance traveled if air resistance is negligible?
A) 8.66 m
B) 10 m
C) 5 m
D) 7.5 m
(Correct Answer: A)

**📌 Activity 2: Using the Pythagorean Theorem in Catapult Motion**

**Objective:** Students apply the Pythagorean Theorem to calculate projectile height.
**Materials Needed:** Graph paper, ruler, calculator, launch data.
**Student Task:**

1. Launch a projectile at a set angle and measure its total distance.
2. Record the time it takes to reach peak height.
3. Use the Pythagorean Theorem to determine maximum height.
4. **Discuss:** How do different angles affect the height and distance relationship?

**📌 Activity 3: Statistical Analysis of Catapult Accuracy**

**Objective:** Students analyze data from multiple launches to determine accuracy.
**Materials Needed:** Catapult, measuring tape, target, notebook.
**Student Task:**

1. Set up a target at 3 meters away and launch projectiles.
2. Record hits and misses, calculate percentage accuracy.
3. Graph results and analyze patterns in precision and consistency.
4. **Discuss:** What design modifications could improve accuracy?

**SCIENCE – ACT Alignment: Physics & Energy Transfer**

The **ACT-aligned Science** component of the Build Your Own Catapult kit explores physics concepts like projectile motion, Newton’s Laws, and energy transfer. Students conduct hands-on experiments to analyze the effects of force, mass, and elasticity on launch distance and accuracy. By measuring kinetic and potential energy, they gain insights into energy conservation and efficiency. The kit also reinforces data interpretation skills by encouraging students to observe patterns, test hypotheses, and refine their designs, aligning with ACT Science principles of experimental analysis and problem-solving.

🔹 **ACT Science Rating Scale – Mechanics & Experimental Design**
• (16-19) Identifying basic forces in motion.
• (20-23) Understanding Newton’s Laws of Motion.
• (24-27) Analyzing experimental results related to energy transfer.
• (28-32) Applying physics concepts to improve efficiency.
• (33-36) Designing and testing catapult optimization experiments.

**📌 Activity 1: Newton’s Laws & Catapult Motion**

**Objective:** Students observe and apply Newton’s Laws to catapult mechanics.
**Materials Needed:** Catapult, stopwatch, weights, notebook.
**Student Task:**

1. Experiment with different projectile weights and record motion changes.
2. Identify how Newton’s First, Second, and Third Laws apply to launches.
3. **Discuss:** How does increasing force impact acceleration?

**📌 Activity 2: Kinetic vs. Potential Energy in Catapult Launches**

**Objective:** Students compare stored potential energy to kinetic energy output.
**Materials Needed:** Rubber bands, different-sized projectiles, spring scale.
**Student Task:**

1. Measure stored energy in the stretched rubber band using a spring scale.
2. Launch projectiles and calculate kinetic energy.
3. Compare energy values and discuss efficiency.

**📌 Activity 3: Elasticity & Energy Transfer Experiment**

**Objective:** Students test how elasticity affects projectile motion.
**Materials Needed:** Rubber bands of varying thickness, ruler, force meter.
**Student Task:**

1. Launch projectiles using different bands, measure force applied.
2. Compare how elasticity affects launch distance and speed.
3. **Discuss:** How does elasticity contribute to stored energy?

**READING – ACT Alignment: Comprehension & Interpretation**

The **ACT-aligned Reading** component of the Build Your Own Catapult kit enhances students' ability to comprehend and analyze technical and historical texts. By studying medieval catapult designs and modern engineering principles, students develop skills in identifying main ideas, interpreting cause-and-effect relationships, and evaluating scientific explanations. Through ACT-style questions, they practice making inferences, comparing perspectives, and synthesizing information from multiple sources, strengthening their ability to understand and apply complex concepts in STEM-related readings.

🔹 **ACT Reading Rating Scale – Scientific & Technical Comprehension**
• (16-19) Understanding key engineering and physics concepts.
• (20-23) Making inferences about catapult mechanics.
• (24-27) Analyzing cause-and-effect in projectile motion.
• (28-32) Evaluating experimental designs.
• (33-36) Synthesizing multiple sources of engineering principles.

**📌 Activity 1: Reading & Analyzing a Historical Catapult Document**

**Objective:** Students interpret historical catapult designs and engineering principles.
**Materials Needed:** Excerpts from historical military texts, reading guides.

**Student Task:**

1. Read about medieval catapult designs and their impact on warfare.
2. Compare historical efficiency with modern engineering.
3. **Discuss:** How did early engineers optimize launch power?

**ACT Question Example:**
According to the passage, what was the primary purpose of catapults in medieval warfare?
A) To destroy enemy morale
B) To launch soldiers over castle walls
C) To breach fortifications
D) To test engineering theories
(Correct Answer: C)

**Activity 2: Read & Compare – How a Catapult Works**

**Objective:** Students read a short passage and answer a question that helps them practice ACT-style reading skills.
**Materials Needed:** One short passage (below), Question sheet or notebook

**Student Task:**

1. Read the passage below carefully.
2. Think about the key idea and any details that help you understand how catapults have changed over time.
3. Answer the multiple-choice question that follows.
4. Be ready to share or explain your answer with a partner or the class.

**Student Passage:**

*A catapult is a machine that uses stored energy to throw an object. In medieval times, catapults were used during battles to launch stones at castle walls. Today, engineers study catapults to understand energy, motion, and force. Modern versions use rubber bands or springs instead of ropes and weights.*

**ACT Question Example:**
What is one way modern catapults are different from medieval ones?
 A) They are used to launch people.
 B) They are made of stone.
 C) They use rubber bands or springs.
 D) They are powered by water.
 **Correct Answer: C**

**📌 Activity 3: Evaluating Scientific Articles on Projectile Motion**

**Objective:** Students analyze and summarize scientific explanations of projectile physics.
**Materials Needed:** Science journal articles on motion, highlighters.
**Student Task:**

1. Read an article on projectile motion and highlight key concepts.
2. Identify main ideas and supporting details.
3. **Discuss:** How do different launch angles affect flight paths?

**ACT Question Example:**
Based on the article, which of the following factors has the greatest impact on projectile range?
A) Air resistance
B) Initial velocity
C) Surface texture of the projectile
D) Color of the projectile
(Correct Answer: B)

**WRITING – ACT Alignment: Argumentation, Explanatory Writing & Technical Communication**

The Build Your Own Catapult kit aligns with ACT Writing standards by strengthening students' ability to construct clear explanations, develop argumentative essays, and refine technical communication. Through structured writing exercises, students articulate scientific and engineering concepts, defend design choices using evidence, and edit technical documents for clarity. These activities help students develop logical organization, precise language, and analytical reasoning—essential skills for ACT Writing success and real-world STEM communication.

🔹 **ACT Writing Rating Scale – Analytical & Technical Writing**
• (16-19) Developing clear and structured paragraphs.
• (20-23) Using evidence to support claims in explanatory writing.
• (24-27) Refining coherence and logical flow in engineering documentation.
• (28-32) Constructing well-reasoned arguments on design improvements.
• (33-36) Synthesizing data and engineering principles in persuasive writing.

**📌 Activity 1: Writing a Technical Explanation of a Catapult’s Mechanics**

**Objective:** Students practice writing clear and structured explanations of the physics behind catapult motion.
**Materials Needed:** Notes on projectile motion, Newton’s laws, energy transfer; example technical articles; writing rubric.

**Student Task:**

1. Write a step-by-step explanation of how a catapult functions, focusing on forces, motion, and energy.
2. Use precise terminology (e.g., kinetic energy, projectile motion, tension) and provide examples.
3. **Discuss:** How do engineering principles affect a catapult’s efficiency?

**Essay Prompt:** Explain the relationship between launch angle and projectile distance in a catapult. Use scientific evidence to support your explanation.

**ACT Question Example:**
Which of the following revisions best improves clarity in a technical explanation of catapult motion?
A) "A catapult moves when you release the arm, sending stuff flying far."
B) "Upon release, stored potential energy in the catapult arm converts into kinetic energy, propelling the projectile forward."
C) "If you let go, the object will go forward because of energy."
D) "The arm goes down and then up, launching the object using physics."
(Correct Answer: B)

**📌 Activity 2: Argumentative Writing – The Best Catapult Design**

**Objective:** Students craft a persuasive essay arguing for the most effective catapult design based on data analysis.
**Materials Needed:** Data from catapult tests, research on historical and modern catapults, writing guide.

**Student Task:**

1. Research different types of catapults (e.g., trebuchet, ballista, mangonel).
2. Write a structured argumentative essay defending one design as the most efficient.
3. Use data (launch distance, accuracy, force application) to support claims.

**Essay Prompt:** Based on historical data and experimental results, which catapult design is the most effective for long-distance projectile launches? Defend your argument with evidence.

**ACT Question Example:**
Which statement best serves as a strong thesis for an argumentative essay about catapult design?
A) "Trebuchets were big and cool-looking."
B) "Catapults are fun to build and use for science experiments."
C) "Due to their counterweight mechanism and energy efficiency, trebuchets are the most effective long-range catapult design."
D) "Catapults have been around for centuries and used in many battles."
(Correct Answer: C)

**📌 Activity 3: Editing & Improving Clarity in a Catapult Assembly Manual**

**Objective:** Students refine technical writing by improving clarity and precision in instructional materials.
**Materials Needed:** Poorly written assembly instructions for a catapult, writing tools, editing checklist.

**Student Task:**

1. Analyze a set of vague or unclear catapult assembly instructions.
2. Rewrite the steps for improved clarity, conciseness, and logical sequencing.
3. **Discuss:** How does technical precision impact the success of an engineering project?

**ACT Question Example:**
Which revision best improves the clarity of an instructional step?
A) "Put the thingy in the slot and make sure it works."
B) "Attach the wooden arm to the base using two screws, ensuring the arm can pivot freely."
C) "Take a part and put it somewhere so it stays steady."
D) "Assemble it like the picture shows, then try it out."
(Correct Answer: B)

**ENGLISH – ACT Alignment: Technical Writing & Grammar**

The **ACT-aligned English** component of the Build Your Own Catapult kit focuses on grammar, sentence structure, and clarity in technical writing. Students refine their editing skills by correcting grammatical errors, restructuring poorly written instructions, and improving clarity in engineering explanations. Through ACT-style questions, they practice identifying sentence errors, improving conciseness, and analyzing the effectiveness of written communication, ensuring they can convey complex STEM concepts with precision and accuracy.

🔹 **ACT English Rating Scale – Grammar & Rhetorical Skills**
• (16-19) Identifying errors in technical descriptions.
• (20-23) Editing for clarity and conciseness.
• (24-27) Recognizing effectiveness in engineering writing.
• (28-32) Refining writing for logical flow and precision.
• (33-36) Synthesizing multiple sources for clear technical explanations.

**📌 Activity 1: Editing a Catapult Construction Manual**

**Objective:** Students refine a poorly written instruction manual.
**Materials Needed:** Sample manual with grammar errors, editing tools.
**Student Task:**

1. Identify sentence structure, punctuation, and clarity issues.
2. Rewrite steps for better readability.
3. **Discuss:** Why is precision critical in technical writing?

**📌 Activity 2: Rhetorical Analysis of a Catapult Engineering Review**

**Objective:** Students evaluate persuasive writing techniques in an article.
**Materials Needed:** Speaker review excerpt, highlighters.
**Student Task:**

1. Analyze tone, clarity, and effectiveness in a catapult product review.
2. Identify rhetorical strategies used.
3. **Discuss:** How do authors shape reader perception?

**📌 Activity 3: Crafting a Persuasive Engineering Proposal**

**Objective:** Students write a proposal to improve a catapult’s design.
**Materials Needed:** Research articles, writing templates.
**Student Task:**

1. Develop an argument for a structural modification.
2. Support claims with physics and math data.
3. **Discuss:** How do engineers justify design improvements?