Gears, Ratios & a Letter to Jefferson

Grades 6–8 · 3 sessions of 50 minutes · Math · Engineering · U.S. History · ELA

Book: *Ticktock Banneker's Clock* by Shana Keller, illustrated by David C. Gardner (Sleeping Bear Press, 2016). CBC Best STEM Book. Lexile 720L. A picture book makes a quick, strong hook for middle schoolers. Read it in about 8 minutes.

Big idea: To make a clock keep time, Banneker had to get the math right: every hand-carved gear needed the right number of teeth. Later, he used that same scientific reputation to challenge Thomas Jefferson on slavery. Students work with ratios through gear trains, analyze a primary source, and argue from evidence.

Learning goals

- Use ratios and proportional relationships to explain how gear trains make clock hands move at different speeds.
- Analyze Banneker's 1791 letter to Jefferson for point of view, purpose and evidence.
- Compare a secondary source (the picture book) with primary sources.
- Fact-check popular claims about Banneker and write an evidence-based argument.

CCSS checklist

Check	Standard	What students do
☐	6.RP.A.1 · 6.RP.A.3	Describe and use gear-tooth ratios; solve ratio problems (gear math #1–4).
☐	7.RP.A.2	Recognize the proportional relationship between minute-hand and hour-hand turns (gear math #5).
☐	7.G.B.4	Use the circumference formula to estimate how many teeth fit on a gear (gear math #6).
☐	RH.6-8.1	Cite specific textual evidence from the letter to support analysis.
☐	RH.6-8.2	Determine the central idea of the letter; summarize it without opinion.
☐	RH.6-8.6	Identify Banneker's point of view and purpose (loaded language, the Declaration quote).
☐	RH.6-8.8	Distinguish among fact, opinion and reasoned judgment (myth check).
☐	RH.6-8.9	Analyze the relationship between the picture book (secondary) and the letter (primary).
☐	WHST.6-8.1	Write an argument with a claim, evidence and reasoning.
☐	WHST.6-8.8	Gather information from several sources and judge whether each is credible.

Cross-curricular connections

Subject	Connection
Engineering	Gear trains and design constraints, such as building with hand tools and wood (NGSS MS-ETS1-1, MS-ETS1-4).
U.S. History	The Declaration of Independence versus the reality of slavery in 1791; Banneker's almanacs and the survey of Washington, D.C.
ELA	Rhetoric in a primary source; argument writing.
Media literacy	Fact-check popular Banneker myths against reliable sources.

Materials

- The book or read-aloud video
- Printables in this packet: gear math, primary source organizer, myth check and argument planner
- Optional: LEGO or cardboard gears, rulers, calculators

Links for teachers

- Watch Shana Keller read *Ticktock Banneker's Clock* (YouTube)
- Hamilton cast read-along (Gilder Lehrman Institute)
- Banneker's letter to Jefferson, Aug. 19, 1791 (National Archives, Founders Online)
- Jefferson's reply, Aug. 30, 1791 (Founders Online)
- The Letters of Banneker & Jefferson (National Park Service)
- Benjamin Banneker, Today in History (Library of Congress)
- Benjamin Banneker (Monticello encyclopedia)
- A Walk Through Time: Early Clocks (NIST)
- Mythology of Benjamin Banneker (Wikipedia, for fact-checking practice)
- Make Your Own Almanac (shanakeller.com)
- Benjamin Banneker Historical Park & Museum (Baltimore County)

Lesson steps

Session 1 · The math inside a clock (Math + Engineering)

- **Hook (10 min):** Read the book or play the video. Ask: "Banneker carved every gear by hand. What did he have to get exactly right?"
- **Mini-lesson (10 min):** When a 48-tooth gear drives a 12-tooth gear, the small one turns 4 times for each big turn (48:12 = 4:1). A clock needs the minute hand to turn 12 times for each turn of the hour hand, a 12:1 ratio.
- **Practice (25 min):** Gear math printable. Grade 6: #1–4. Grades 7–8: all.
- **Exit (5 min):** "Why couldn't Banneker just guess the number of teeth?"

Session 2 · Reading a primary source (History + ELA)

- **Context (10 min):** Use the Library of Congress and NPS pages. In 1791 Banneker sent Secretary of State Jefferson a manuscript of his almanac with a letter.
- **Close read (25 min):** Students read the excerpts on the organizer (full text at Founders Online) and complete the SOAPS-style questions.
- **Compare (10 min):** How does the picture book show Banneker? What does the letter show that the book doesn't? (RH.6-8.9)
- **Discuss (5 min):** Read Jefferson's reply (link). Was it a real answer to Banneker's challenge?

Session 3 · Myth check and argument (ELA + Media literacy)

- **Myth check (20 min):** Teams test 4 claims against the linked sources and label each fact, myth or partly true.
- **Argument (30 min):** "What was Banneker's most important achievement: his clock, his almanacs, or his letter to Jefferson?" Claim, 2 pieces of evidence, reasoning.

Differentiation and teacher notes

- **Support:** provide the letter excerpts with a vocabulary box (*benevolence, impartial, counteract, captivity*); allow a paragraph instead of an essay.
- **Challenge:** design a compound gear train that gives exactly 12:1 using no gear larger than 40 teeth.
- **Sensitive topic:** the letter addresses slavery directly. Set discussion norms first and keep the focus on Banneker's argument and evidence.

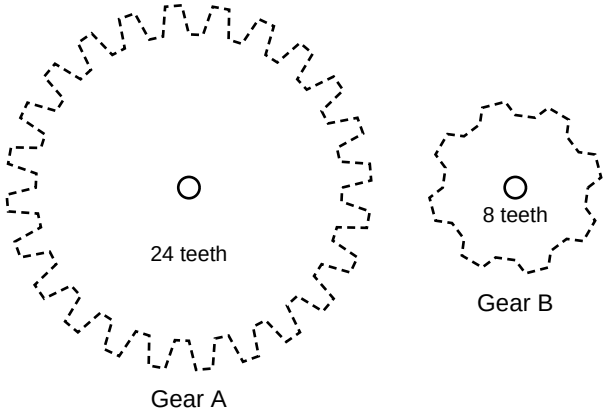
Answer key

Gear math: 1) 4:1; 4 turns 2) 20 turns 3) 12:1; minute hand 24 turns, hour hand 2 turns 4) answers vary, e.g. 36→12 (3:1) and 40→10 (4:1); 3 × 4 = 12 5) hour turns = minute turns ÷ 12; constant of proportionality 1/12 6) $C = \pi \times 4 \approx 12.6$ in; about 25 teeth. **Myth check:** A) Myth: clocks had been made in the colonies before 1753; Banneker's was notable as a self-taught, hand-carved striking clock. B) Partly true: he helped Andrew Ellicott survey the boundaries of the federal district, but the story that he redrew L'Enfant's plan from memory is a myth. C) Fact: he published almanacs in the 1790s. D) Fact: he wrote to Jefferson in August 1791.

Gear Math: Inside Banneker's Clock

Show your work. Use the gears to picture each problem.

Name: _____ Date: _____



Key idea: When two gears touch, every tooth that passes on one gear passes on the other. So the gear with fewer teeth turns more times.

Here Gear A has 24 teeth and Gear B has 8: 24:8 = 3:1, so B turns 3 times for every 1 turn of A.

1. Gear A (48 teeth) drives Gear B (12 teeth). Write the ratio of teeth A:B in simplest form. _____ When A turns once, how many times does B turn? _____

2. A 60-tooth gear drives a 15-tooth gear. If the big gear turns 5 times, how many times does the small gear turn? _____

3. In a clock, the minute hand turns 12 times for every 1 turn of the hour hand. Write this ratio. _____ In one full day (24 hours), how many turns does the minute hand make? _____ The hour hand? _____

4. A single pair of gears for 12:1 would need a huge gear. Design two gear pairs whose ratios multiply to 12:1. Pair 1: ____ teeth drives ____ teeth (ratio ____) · Pair 2: ____ teeth drives ____ teeth (ratio ____)

5. (Grade 7–8) Complete the table, then write an equation for hour-hand turns (h) in terms of minute-hand turns (m).

Minute-hand turns (m)	12	24	36	60
Hour-hand turns (h)				

Equation: h = _____ Constant of proportionality: _____

6. (Grade 7–8) Banneker carves a wooden gear 4 inches across. Find its circumference (use $\pi \approx 3.14$). _____ If he spaces teeth every 0.5 inch around the edge, about how many teeth fit? _____

Primary Source: Banneker's Letter to Jefferson (1791)

Excerpts in Banneker's original spelling. Full text: founders.archives.gov

Name: _____ Date: _____

A	"Sir I freely and Chearfully acknowledge, that I am of the African race"
B	"a copy of which I have taken the liberty to direct to you" (his almanac), which he made "thro my own assiduous application to Astronomical Study"
C	Banneker quotes Jefferson's own words: "We hold these truths to be Self evident, that all men are created equal"
D	"how pitiable is it to reflect, that altho you were so fully convinced of the benevolence of the Father of mankind ... that you should at the Same time counteract his mercies, in detaining by fraud and violence so numerous a part of my brethren under groaning captivity and cruel oppression"

Question	Your answer (cite the excerpt letter)
Speaker: Who wrote this, and what gave him credibility with Jefferson?	
Occasion: When and why was it written?	
Audience: Who was Jefferson in 1791, and why does that matter?	
Purpose: What does Banneker want Jefferson to think or do?	
Strategy: Why does he quote the Declaration (C)? How does it strengthen his argument?	
Primary vs. secondary: What does this letter show about Banneker that the picture book doesn't?	

Myth Check + Argument Planner

Test each claim against at least one reliable source. Write the source you used.

Name: _____ Date: _____

Claim	Fact, myth or partly?	Source and evidence
A. Banneker built the first clock ever made in America.		
B. Banneker helped survey the land for Washington, D.C.		
C. Banneker published almanacs in the 1790s.		
D. Banneker wrote to Thomas Jefferson in 1791.		

Which source was most reliable, and why? _____

Argument: What was Banneker's most important achievement?

My claim (clock, almanacs, or letter):	
Evidence 1 (with source):	
Evidence 2 (with source):	
Reasoning: why this evidence proves my claim	
Counterclaim and my response	