Reverse Engineer Like Banneker

Grades 3–5 · 3 sessions of 45 minutes · ELA · Math · Engineering · Social Studies

Book: *Ticktock Banneker's Clock* by Shana Keller, illustrated by David C. Gardner (Sleeping Bear Press, 2016). CBC Best STEM Book. Lexile 720L.

Big idea: Banneker learned how a clock worked by taking a close look at a watch and then building his own, a process engineers call reverse engineering. Students trace his design process with evidence from the text, use clock math (time, conversions and angles), and then design their own one-minute timer.

Learning goals

- Explain the steps Banneker took and why, using details from the text.
- Solve elapsed-time, unit-conversion and clock-angle problems.
- Plan, build, test and improve a simple timer, then compare the process to Banneker's.
- Write an informative paragraph about why Banneker's work mattered.

CCSS checklist

Check	Standard	What students do
☐	RI.4.1 · RI.5.1	Refer to and quote details from the text when explaining Banneker's process.
☐	RI.4.3 · RI.5.3	Explain the steps (procedure) Banneker followed and the relationships between them (design journal).
☐	RI.4.4 · RI.5.4	Determine the meaning of domain words: *almanac, gear, pendulum, strike, surveyor, reverse engineer*.
☐	W.4.2 · W.5.2	Write an informative paragraph: why Banneker's clock mattered.
☐	W.4.7 · W.5.7	Short research using the linked Library of Congress and NIST pages.
☐	SL.4.1 · SL.5.1	Team discussions during the design challenge.
☐	4.MD.A.1 · 5.MD.A.1	Convert hours, minutes and seconds (clock math, part 2).
☐	4.MD.A.2	Solve word problems with intervals of time (clock math, part 1).
☐	4.MD.C.5	Understand angles as turns within a circle of 360°; measure the angles between clock hands (part 3).

Cross-curricular connections

Subject	Connection
Engineering	Reverse engineering and the design cycle; one-minute timer challenge (NGSS 3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3).
Social Studies	Colonial Maryland; Banneker as a free Black farmer, mathematician and almanac author in the 1700s.
Science	Measuring time with steady, repeating motion (gears, pendulums, dripping water).
Math	Elapsed time, unit conversions and angles on a clock face.

Materials

- The book or read-aloud video
- Timer challenge, per team: 2 paper cups, pushpin, water, tape, stopwatch or phone timer
- Printables in this packet: design journal, clock math, timer challenge log

Links for teachers

- Watch Shana Keller read *Ticktock Banneker's Clock* (YouTube)
- Hamilton cast read-along (Gilder Lehrman Institute)
- Ticktock activity guide & coloring page (shanakeller.com)
- Make Your Own Almanac (shanakeller.com)
- Banneker's Famous Math Riddle (shanakeller.com)
- Benjamin Banneker, Today in History (Library of Congress)
- A Walk Through Time: Early Clocks (NIST)
- Benjamin Banneker Historical Park & Museum (Baltimore County)

Lesson steps

Session 1 · Read like an engineer (ELA + Social Studies)

- **Hook (5 min):** Show a closed pocket watch (or a photo). "How could you figure out how this works without instructions?" Introduce *reverse engineering*.
- **Read aloud (15 min):** As you read, students note each step Banneker took and how he solved problems.
- **Context (5 min):** Share 2–3 facts from the Library of Congress page: free-born in Maryland in 1731, mostly self-taught, later wrote almanacs and helped survey the land for Washington, D.C.
- **Design journal (20 min):** Partners fill in the left column with text evidence for each design step.

Session 2 · Clock math (Math)

- **Warm-up (5 min):** "A clock face is a circle. How many degrees in a full turn?"
- **Model (10 min):** Show why each hour mark is 30° (360 ÷ 12) and each minute mark is 6° (360 ÷ 60).
- **Practice (25 min):** Clock math printable. Grade 3: part 1 and part 2 #1–2. Grades 4–5: all parts.
- **Extension:** Banneker's Famous Math Riddle (link above).

Session 3 · One-minute timer challenge (Engineering + Writing)

- **Challenge (5 min):** "Using only the materials, build a timer that measures exactly 1 minute."
- **Plan, build, test (25 min):** Teams poke holes in a cup, time how long the water takes to drain, and adjust (hole size, water amount). Record 3 trials on the log.
- **Reflect (5 min):** Fill in the right column of the design journal: how was our process like Banneker's?
- **Write (10 min or homework):** Informative paragraph: "Why Benjamin Banneker's clock mattered."

Differentiation

- **Support:** sentence frames for the journal ("First Banneker ___, so ___"); clock math parts 1–2 only.
- **Challenge:** find the angle between the hands at 2:30 (hour hand moves too!); build a 2-minute timer.
- **Grade 5:** add the almanac extension: students create one almanac page with sunrise/sunset times and weather notes.

Assessment

- Design journal cites at least 4 details from the text (RI.x.1, RI.x.3)
- Clock math accuracy (MD standards)
- Timer log shows a change made after testing (ETS1)
- Informative paragraph: topic sentence, 3 facts, conclusion (W.x.2)

Answer key: Clock math

Part 1: 1) 2 h 35 min 2) 9:10 p.m. 3) 24 months, about 104 weeks · **Part 2:** 1) 180 min 2) 120 sec 3) 3,600 sec 4) 86,400 sec · **Part 3:** 1) 30° 2) 90° 3) 180° 4) 120° 5) 6° · **Bonus:** 78 strikes (1+2+…+12); 156 in a full day. 2:30 challenge: 105°.

Engineering Design Journal

Left: evidence from the book. Right: what your team did in the timer challenge.

Name: _____ Date: _____

Design step	What Banneker did (text evidence)	What our team did
Ask What problem or question?		
Research How did he learn?		
Plan What did he draw or decide?		
Build What tools and materials?		
Test What happened?		
Improve What did he change?		

Reverse engineering means figuring out how something works by studying it closely, then using what you learn to build something new.

Clock Math with Banneker

Show your work. Use the clock face to help with angles.

Name: _____ Date: _____

Part 1 · Elapsed time

1. Banneker worked on his clock from 6:45 p.m. to 9:20 p.m. How long did he work? _____

2. He started at 7:25 p.m. and worked 1 hour 45 minutes. What time did he stop? _____

3. Banneker spent about 2 years building his clock. About how many months is that? _____ About how many weeks? _____

Part 2 · Convert units

1. 3 hours = _____ minutes

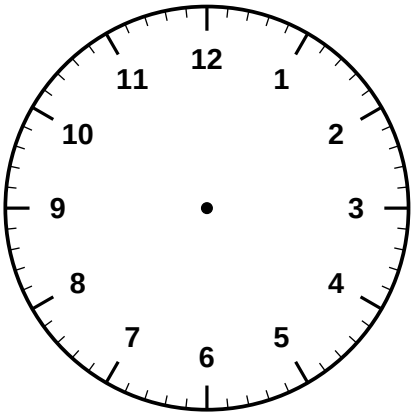
2. 2 minutes = _____ seconds

3. 1 hour = _____ seconds

4. (Grade 5) 1 day = _____ seconds

Part 3 · Angles on a clock

1. A full turn is 360°. There are 12 hour marks. How many degrees between each hour mark? _____
2. Angle between the hands at 3:00? _____
3. At 6:00? _____
4. At 4:00? _____
5. The minute hand goes all the way around in 60 minutes. How many degrees does it move each minute? _____



Draw 3:00, then 4:00

Bonus: A striking clock rings once at 1:00, twice at 2:00, and so on up to 12 times at 12:00. How many strikes in 12 hours? _____ In a whole day? _____

One-Minute Timer Challenge

Goal: a water timer that drains in exactly 60 seconds.

Name: _____ Date: _____

Our plan (sketch your timer and label the parts):

Trial	Time (seconds)	How far from 60?	What we will change next
1			
2			
3			
4			

How is your timer like Banneker's clock? How is it different?

Why does a clock need something that moves at a steady speed?