

BotForge: Keep the Spinner Spinning

Ages 10-14 · about 45 minutes, in one sitting

Your child opens a combat robot whose spinning blade empties its battery in under 7 seconds and then cuts out mid-fight. They read three numbers the app shows and work out the run time themselves: the battery divided by what is lost each second. Then they find the lightest battery cells that keep the blade spinning for at least 15 seconds, because every kilogram spent on cells is weight the robot cannot use for anything else.

What you need

- A computer or Chromebook with a current browser. The robot is drawn in 3D, so an older computer turns it more slowly.
- The lesson link: mytekdev.com/try/botforge?lesson=keep-the-spinner-spinning&ref=fam-botforge-1. No account, no email and nothing to install.
- Optional: the activity sheet at the end of this plan, printed, a pencil, and a calculator (the computer's own is fine).

Do it together

1. Open mytekdev.com/try/botforge?lesson=keep-the-spinner-spinning&ref=fam-botforge-1 together. A short guide runs along the bottom; follow it: press **Power** on the left and read the warning on the right, then open **Stats** at the top right. Ask: what does that warning mean in a fight?

You'll know it worked when: Your child has read the warning: firing everything empties the battery in about 7 seconds, then the weapons cut out.

2. Press Power on the left again to bring its numbers back, and work this out before looking at Stats again. Find the three numbers in the Power panel: **Battery (burst)** 50 u, **Recharge (sustain)** 10.0 u/s, and under **Power draw**, **Total (all firing)** 17.5 u/s. Work it out together: every second the blade uses 17.5 and the battery gets 10 back, so it loses 7.5 each second. The battery holds 50, so it lasts $50 / 7.5$, about 6.7 seconds. Then find **Sustained run** in Stats.

You'll know it worked when: Stats says Sustained run 6.7s, the same as your working.

3. Predict, then check. In Power, add a Standard cell from **Add a cell**, then delete the Fast-Charge with the delete control on its row. Before looking at Stats, work out the new run: $50 / (17.5 - 4.5) = 50 / 13$, about 3.8 seconds.

If you get stuck: The last cell cannot be deleted, because a robot always keeps at least one. Add the new cell first.

You'll know it worked when: Stats says Sustained run 3.8s.

4. Add a second Standard cell and predict again before looking: $100 / (17.5 - 9) = 100 / 8.5$.

You'll know it worked when: Your child works out about 11.8 seconds, and Stats agrees.

5. The challenge: find cells that give a Sustained run of 15 seconds or more while weighing as little as possible. **Cell weight** is in the Power panel, and up to four cells fit. Work each try out on paper before checking it in Stats.

If you get stuck: If the tries feel random, start again from the Fast-Charge plus one more cell, so only one cell changes at a time. Fast-Charge plus one Lightweight reaches 14.4 seconds, just short.

You'll know it worked when: Your child finds 11 kg: Fast-Charge plus two Lightweight cells (37.6 seconds), or three Lightweight plus one Standard (21.1 seconds). No set under 11 kg reaches 15 seconds.

6. Ask: why not just add four Heavy Cells? The meter at the top shows the whole robot against its 200 kg limit.

You'll know it worked when: Your child explains that four Heavy Cells weigh 52 kg, more than a quarter of the limit, and that weight cannot go to armor or a bigger weapon.

7. Then the real question, without the app: a battery of 80, a recharge of 12.5 and a draw of 17.5. How long does it last?

You'll know it worked when: Your child works out $80 / 5 = 16$ seconds. That means they understand the rate, not just where to read it.

Talk about it

Ask these while you work together. A child who has understood the lesson can answer them without help:

- How much power does the bot lose each second right now? Where did those numbers come from?
- Why do you subtract before you divide?
- Your cells say unlimited. What does that tell you about recharge and draw?
- This set of cells reaches 15 seconds. Can you find a lighter one?

- Without the app: a battery of 80, recharge 12.5, draw 17.5. How long does it last?

The last one is the real test. A child who works it out ($80 / 5 = 16$ seconds) without the app understands the rate, not just where to read it.

For younger and older kids

Younger: For ages 8 and 9, give the amount lost each second and work only the division, or round the numbers to whole numbers first.

Older: For teens, write the run time as a function of recharge, $t(r) = 50 / (17.5 - r)$, graph it, and explain what happens as r gets close to 17.5.

Keep going

- Find the lightest cells that never brown out. (Fast-Charge plus three Lightweight cells, 13 kg.)
- Open Weapons and pick the blade. Its note says where damage tops out for its size: above that speed, the extra spin only drains the battery. Lower the speed toward that number and watch Sustained run. (At 1000 RPM with one Fast-Charge cell it reads about 20 seconds.) What, if anything, does the bot give up?
- Why does the app call Sustained run the worst case? (It assumes every weapon fires nonstop; in a fight they fire in bursts and the battery refills in between.)

Bring it into other subjects

- Science: a phone battery works the same way. Why does a phone die faster while playing a game than while it sits in a pocket? (The game draws more power each second.)
- Math: graph the battery level over 10 seconds for the starter bot: start at 50 and take away 7.5 each second. When does the line reach zero? (Between 6 and 7 seconds.)
- Engineering: real combat robot builders choose batteries by weight too. Write a sentence on what you would do with the weight your lightest cells saved.
- Programming: a robot that fires in bursts instead of nonstop gives its battery time to refill between hits.

For your records

Ready to copy into an hour log, a portfolio or a transcript.

LESSON	BotForge: Keep the Spinner Spinning
SUBJECTS	Math, Engineering
TIME	45 minutes
WHAT WE DID	Worked out how long a combat robot's battery lasts from its capacity, recharge rate and power draw, predicting each result before checking it in the app. Then searched for the lightest set of battery cells that met a 15-second target and explained the weight trade-off.

SKILLS PRACTICED

rates in units per second; multi-step problems: subtract, then divide; predicting and checking; design trade-offs under a weight limit

Activity sheet (optional)

Name: _____ Date: _____



Open the app: scan the QR code, or go to mytekdev.com/try/botforge?lesson=keep-the-spinner-spinning

Essential question: How long will a battery last, and how can a designer make it last longer?

Lost each second = draw - recharge. Sustained run = battery / lost each second. The starter blade draws 17.5 u/s.

CELLS	BATTERY (U)	RECHARGE (U/S)	LOST EACH SECOND	I WORK OUT	STATS SAYS	CELL WEIGHT
Fast-Charge	50	10				7 kg
Standard						
2 Standard						
My try:						
My try:						
My lightest:						

- Change cells.** Press **Power** on the left. Add cells from **Add a cell**; delete one with the control on its row.
- Check.** Open **Stats** at the top right and read **Sustained run**.

1. Why not just add four Heavy Cells?

Quick check

Name: _____

1. A battery holds 100 u, recharges 10 u/s, and the weapons draw 15 u/s. How long do the weapons last? (A) 20 seconds, (B) 10 seconds, (C) 6.7 seconds.
 2. The recharge is 20 u/s and the weapons draw 17.5 u/s. The sustained run is: (A) 2.5 seconds, (B) 37.5 seconds, (C) unlimited.
 3. Name two ways to make a spinner's battery last longer, and what each one costs.
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Answers

Measured in the app on the starter bot (draw 17.5 u/s, the bot 97 kg without cells):

CELLS	BATTERY	RECHARGE	LOST EACH SECOND	SUSTAINED RUN	CELL WEIGHT
Fast-Charge	50	10	7.5	6.7 s	7 kg
Standard	50	4.5	13	3.8 s	5 kg
2 Standard	100	9	8.5	11.8 s	10 kg
Fast-Charge + Lightweight	72	12.5	5	14.4 s (not quite)	9 kg
Fast-Charge + 2 Lightweight	94	15	2.5	37.6 s	11 kg
3 Lightweight + Standard	116	12	5.5	21.1 s	11 kg
Fast-Charge + Standard	100	14.5	3	33.3 s	12 kg
Fast-Charge + 3 Lightweight	116	17.5	0	unlimited	13 kg

No set of cells under 11 kg reaches 15 seconds.

QUICK CHECK	ANSWER	WHY
1	A	It loses $15 - 10 = 5$ each second, and $100 / 5 = 20$ seconds.
2	C	The recharge is more than the draw, so the battery never loses power.
3	Any two of: add cells (costs weight); use cells with more recharge, like Fast-Charge (costs weight); lower the blade's RPM (no damage lost down to where the Weapons note says damage tops out; weaker hits below that); fire less often (fewer hits)	Any two ways count, each with what it costs.

If your state or umbrella school asks, this lesson covers Common Core Math 5.NBT.B.7, Common Core Math 6.RP.A.3b, NGSS MS-ETS1-2, Common Core Math 6.NS.B.3, NGSS 3-5-ETS1-2.

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The app this lesson uses is free and runs in the browser, with nothing to install and no account needed. It is at mytekdev.com.

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