01

CHANCES OF SURVIVAL: YOU MIGHT MAKE IT

SURVIVAL STRATEGIES: OPERATIONS AND ALGEBRAIC THINKING

DEATH BY: GIANT BLADE

THE PIT AND THE PENDULUM

THE CHALLENGE

The year is 1714. You're in a dark Spanish prison. You wake up to find yourself tied to a table with ropes. In the darkness you hear a rhythmic swishing sound—something going back and forth, back and forth. Eventually your eyes get accustomed to the dark and see that the source of the sound is a sharp blade at the end of a long pendulum

that's swinging back and forth over your body. With each sweep it gets a little lower—and a little closer to your chest.

You note how long it takes between those swishes: exactly 7 seconds. And with each swish, the blade drops 1 inch lower. The last passing was only 15 inches above your chest. It won't be much longer before the blade slices right through you.

Should you scream for help? That would probably just summon a guard, who would run you through with a sword then and there.

But wait! You see a rat by your arms and he's gnawing at the rope that binds you to the table. In fact, he has only 1 minute to go before he gnaws through it all the way. When he does that, you can get free!

Will the rat chew through the rope *before* or *after* the blade has slashed through your chest? How much time do you have exactly?

EUCLID'S ADVICE

You have all the information you need to solve the problem. Basically, it's a race between the rat and the blade on the pendulum.

- **You know how long it will take the rat to gnaw through the rope.**
- **You know how much more the blade must lower before it reaches you, how much it lowers with each swing, and how long it takes between swings.**

WORKSHEET

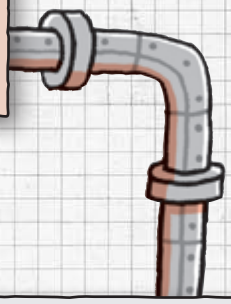
work it out.

THE SOLUTION

THE RAT SHOULD CHEW THROUGH THE ROPE 45 SECONDS BEFORE THE PENDULUM BLADE REACHES YOUR CHEST.

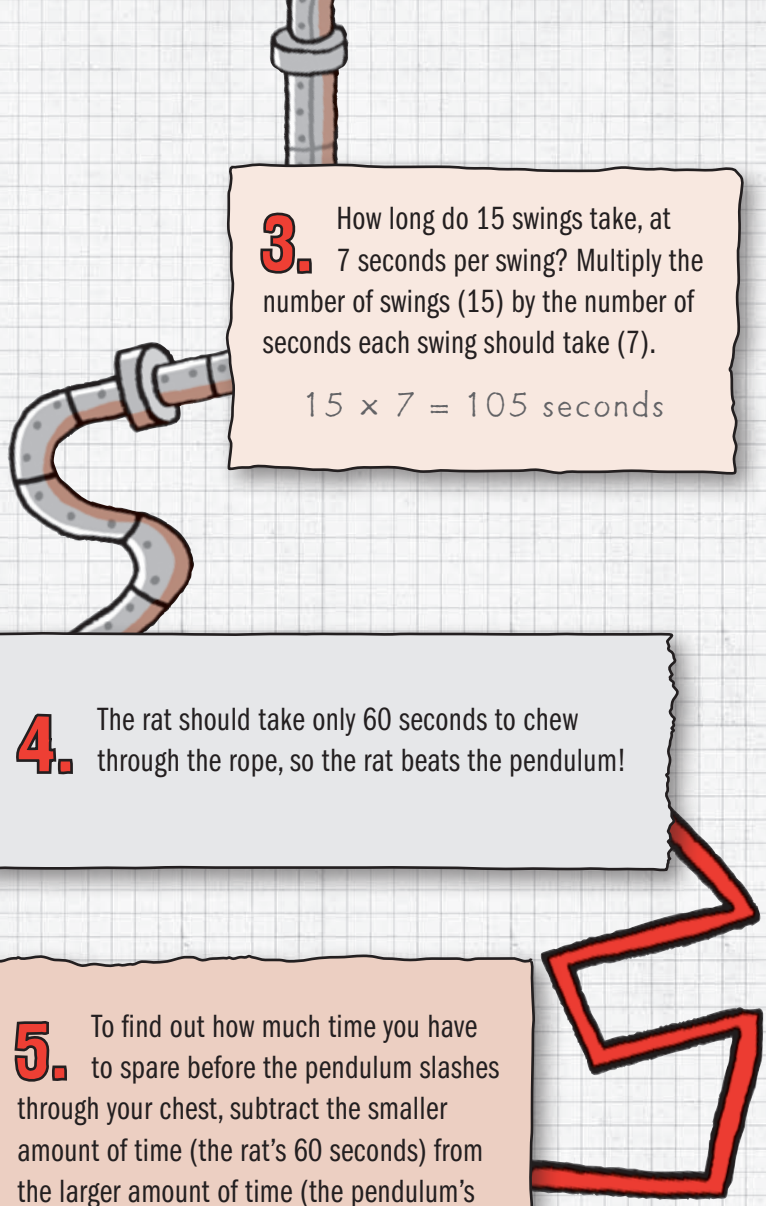
Solve it, step-by-step:

1. You know that the rat will take 1 minute (60 seconds) to chew through the rope.



2. The pendulum blade is 15 inches above your chest and it lowers 1 inch with each swing. How many swings will it take the blade to reach you? Divide the height the blade is above you (15 inches) by the number of inches it drops per swing (1 inch).

$$15 \div 1 = 15 \text{ swings}$$



3. How long do 15 swings take, at 7 seconds per swing? Multiply the number of swings (15) by the number of seconds each swing should take (7).

$$15 \times 7 = 105 \text{ seconds}$$

4. The rat should take only 60 seconds to chew through the rope, so the rat beats the pendulum!

5. To find out how much time you have to spare before the pendulum slashes through your chest, subtract the smaller amount of time (the rat's 60 seconds) from the larger amount of time (the pendulum's 105 seconds).

$$105 - 60 = 45 \text{ seconds}$$

You have 45 seconds to spare before the blade hits you.

Phew! Saved by the rat.

MATH LAB

Try this experiment to get an idea of how you can be so confident about pendulums and their movement.

YOU WILL NEED

- 36 INCHES OF STRING
- KEY
- SCISSORS
- 4 OR 5 HEAVY BOOKS
- TABLE AT LEAST 2½ FEET TALL
- RULER
- WATCH THAT CAN MEASURE SECONDS

THE METHOD

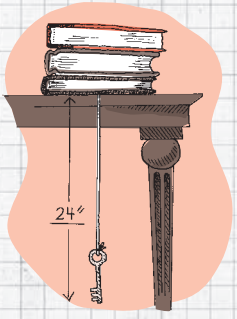
1. Take the 36-inch length of string and the key.

2. Loop one end of the string through the hole in the key and tie securely.

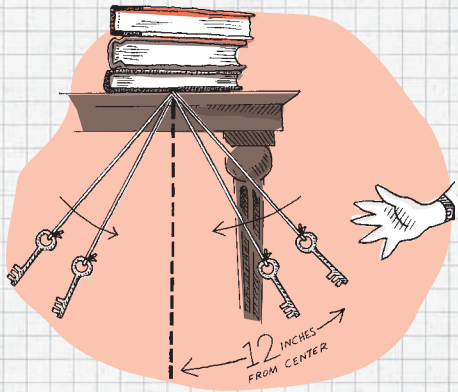
3. Cut off any excess string from the knot and center the knot on the top of the key, so that the key will hang straight, pointing down.

4. Pile the books on the table and slide the other end of the string under them.

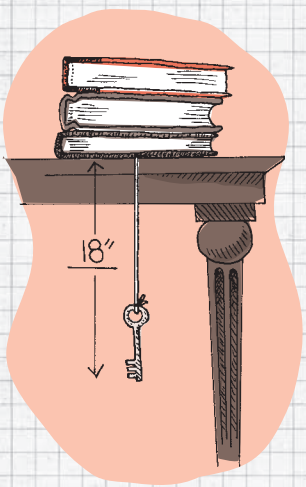
5. Measure the section of string that is hanging down (your pendulum) and adjust it until it is 24 inches from the table edge to the bottom of the key. Slide the string under the books to raise or lower the pendulum.



6. Now pull the pendulum to the left about 12 inches, parallel to the table edge, and count how many times it passes the center in a minute.



7. Stop the swinging, and then pull the pendulum to the left about 6 inches, parallel to the table edge, and count how many times it passes the center in a minute.



8. Now slide the string back through the books so that the pendulum hangs down 18 inches (instead of 24 inches).

9. Repeat steps 6 and 7.

10. What happens when you change the length of the string? What do your results tell you about the movement of pendulums in general?

THE SOLUTION: YOU SHOULD FIND THAT THE NUMBER OF TIMES A PENDULUM OF ANY PARTICULAR LENGTH (24 OR 18 INCHES, IN THIS EXPERIMENT) SWINGS BACK AND FORTH IN A GIVEN TIME (1 MINUTE, IN THIS EXPERIMENT) IS THE SAME, NO MATTER HOW FAR BACK AND FORTH IT SWINGS. THIS NUMBER IS AFFECTED ONLY BY THE LENGTH OF THE PENDULUM.