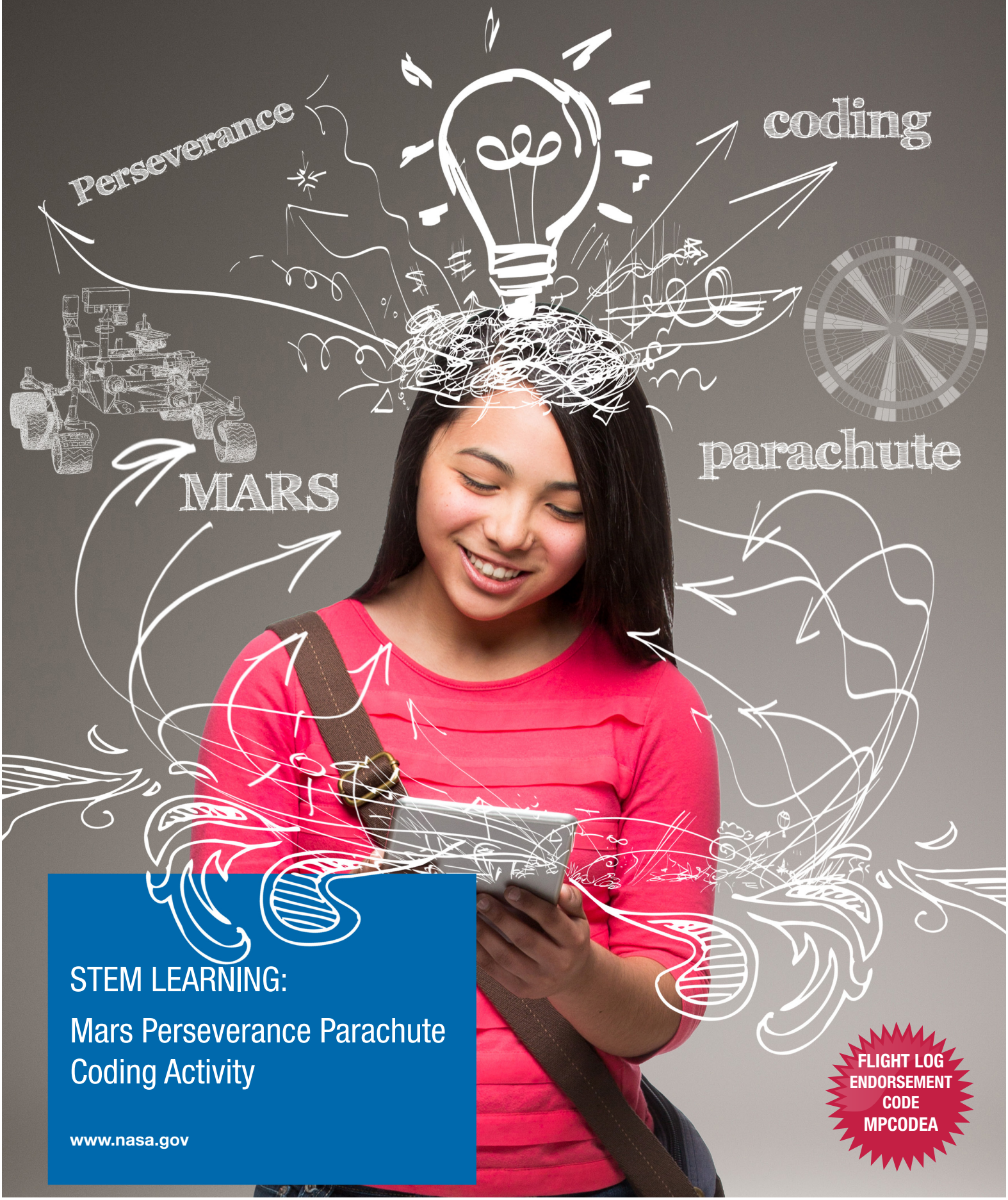
National Aeronautics and Space Administration



STEM LEARNING:

Mars Perseverance Parachute Coding Activity

www.nasa.gov

FLIGHT LOG ENDORSEMENT CODE MPCODEA

MESSAGE IN A (SUPERSONIC) BOTTLE

Some of the people involved with NASA's supersonic parachute that slowed Perseverance's descent onto Mars had a bit of fun with the parachute's design. The red and white pieces of fabric that were designed to help analysts make observations to ensure the parachute deployed properly also contained a message "written" in a binary code. "Dare Mighty Things" and the map coordinates for NASA's Jet Propulsion Laboratory (JPL) are encoded in the design. Take a look at the image of the parachute and the graphic description shown in Figures 1 and 2 for specifics.

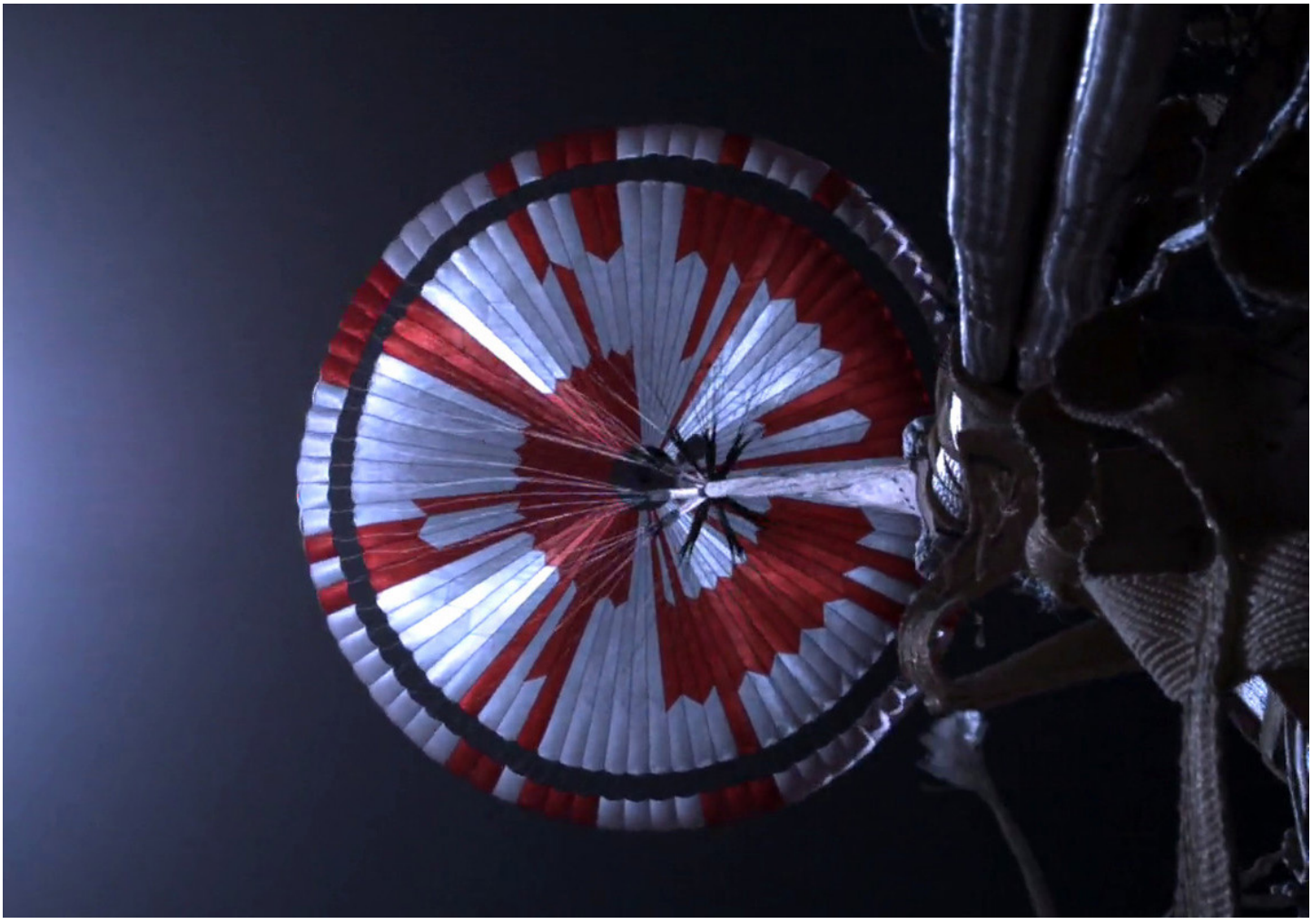


Figure 1- View of Perseverance's parachute as it descends to the Martian surface. Credit: NASA TV

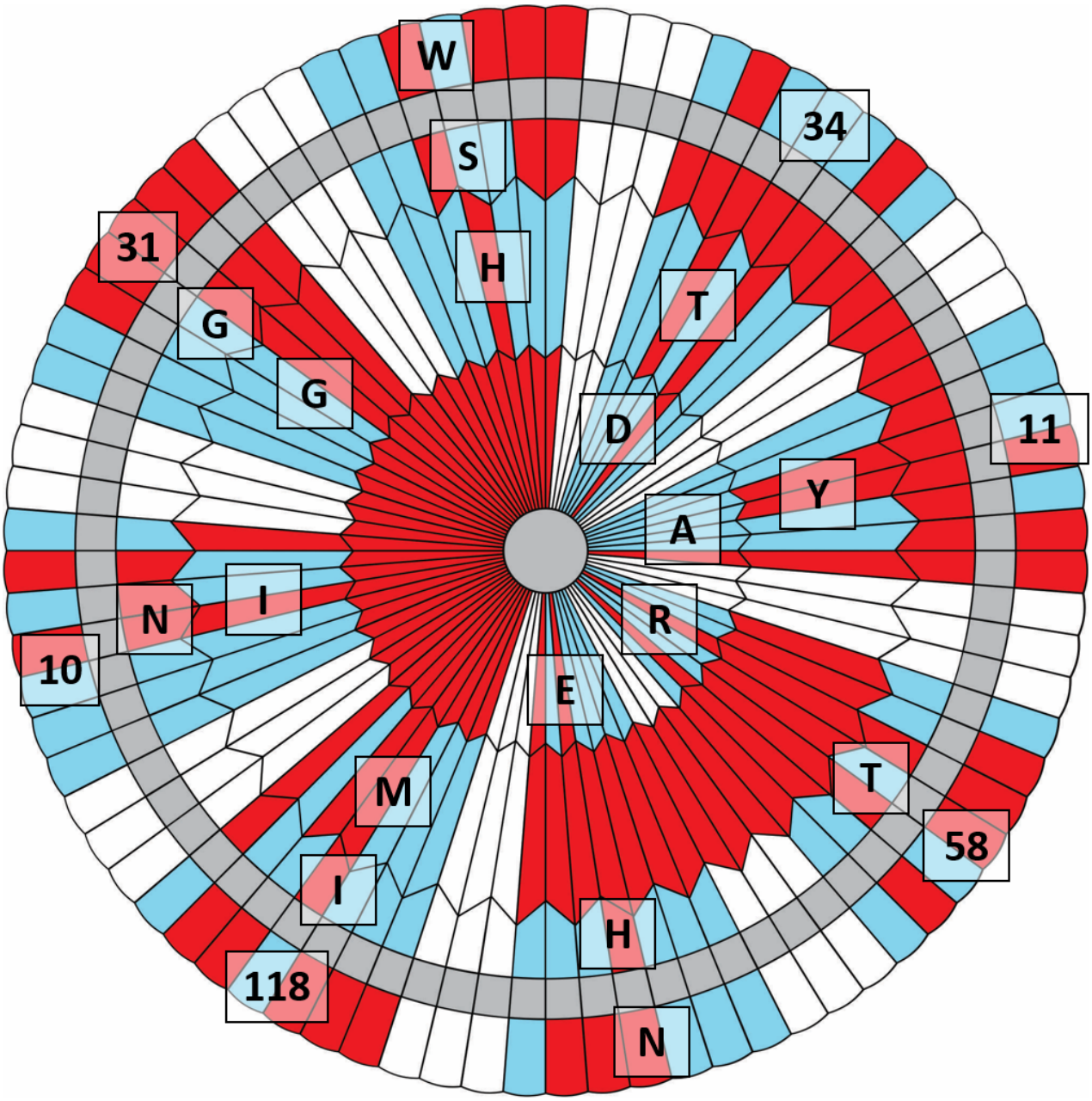


Figure 2- Message decoded.

NOW IT'S YOUR TURN!

Activity Instructions:
In this activity, you are going to create your own message on a parachute using the same code JPL designers used for the parachute that helped Perseverance land safely.

To be able to encode and decode messages, you need to understand what binary numbers are. A binary number is a series of 1s and 0s that represent a number. It can be any length, but for this activity you will be using 7-digit numbers (for example: 0011001). Each place in the number has a value associated with it as shown in *Figure 3*.

Binary Number	0	0	1	1	0	0	1
Place Values	64	32	16	8	4	2	1

Figure 3- Place values for binary numbers.

To convert a binary number to a decimal number, look at each digit. If the digit is a 1, you add the value of that place to the decimal number. If the digit is a 0, you do not add anything to the decimal number. For example, to convert 0011001 to a decimal number, you add 16+8+1 which equals 25 *(see Figure 3)*.

For messages in the parachute, numbers can represent letters according to their place in the alphabet. If the number is a 1, it represents the letter A. If it's a 2, it represents B and so on until 26 represents Z.

Numbers can also be included. For numbers, you just skip the step of converting them into letters.

Practice Code:
Figure 4 shows the code for each letter of the alphabet. Use it to try to decode the message shown in *Figure 5*. To decode the message, start in the innermost ring and work your way outwards, reading the sections clockwise. The first word in the inner ring begins right after the section that is filled in with black. As you move outwards, the words in the second through fourth rings begin right after the end of the word that comes before it. The first word has been completed for you.

Your Code:
Now that you know how to read a code in binary, it is your turn to create your own. Take a look at the following activity, "Make Your Own Message." Happy coding!

Decimal Number	Letter	What It Looks Like	Binary Number
1	A		0000001
2	B		0000010
3	C		0000011
4	D		0000100
5	E		0000101
6	F		0000110
7	G		0000111
8	H		0001000
9	I		0001001
10	J		0001010
11	K		0001011
12	L		0001100
13	M		0001101
14	N		0001110
15	O		0001111
16	P		0010000
17	Q		0010001
18	R		0010010
19	S		0010011
20	T		0010100
21	U		0010101
22	V		0010110
23	W		0010111
24	X		0011000
25	Y		0011001
26	Z		0011010

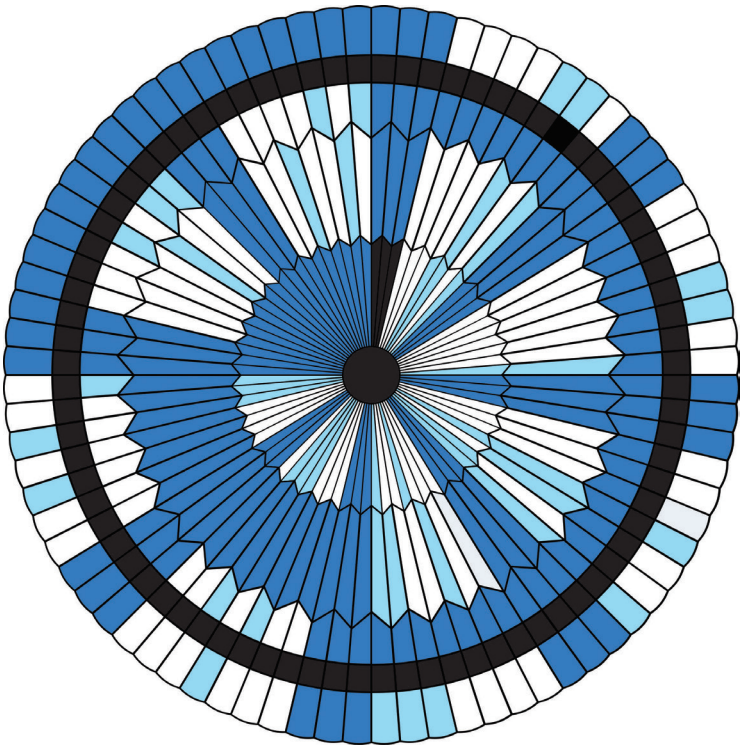


Figure 4- Message to decode.

Figure 5- Values for each letter.

First Word: **M** **A** **K** **I** **N** **G**

Second Word: _____ _____ _____ _____ _____ _____

Third Word: _____ _____ _____ _____

Fourth Word: _____ _____ _____ _____ _____ _____

MAKE YOUR OWN MESSAGE

If you were hiding a message in a parachute like the JPL designers did for the Mars rover, what would it say? Decide what your message would be. It can have up to four words and each word can have up to eight letters. First, convert each letter to its decimal number. Then, convert that to a binary number. Use the information in the table to the right to help you.

Your message should start in the innermost ring, just to the right if the section that is the filled in with black. Work in a clockwise direction. For each letter, color in the spaces that correspond to the 1s in the binary value of the letter and leave the 0s blank. You can use any color(s) you want!

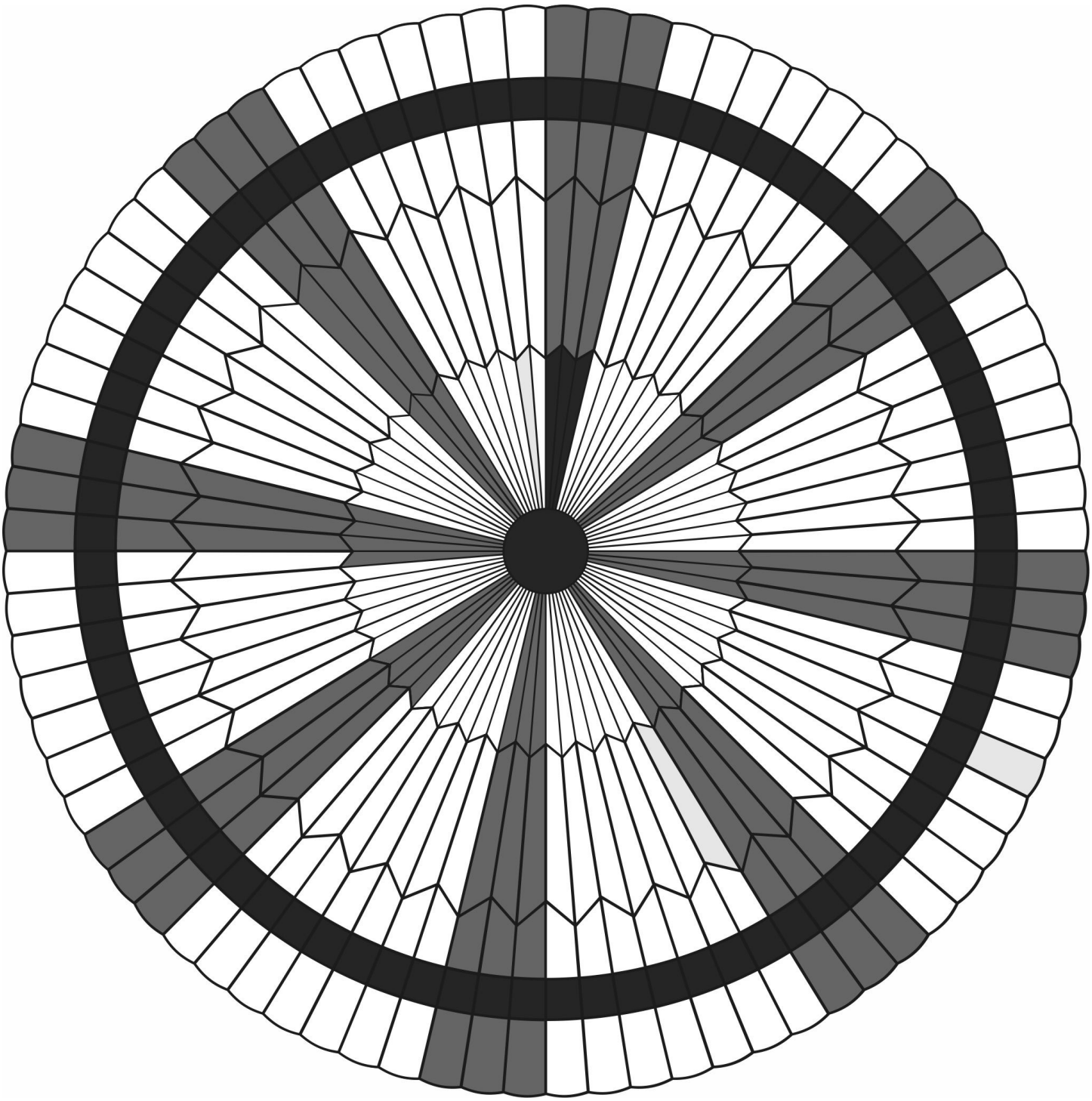
There are spots for up to eight letters in each ring and four rings in total. If you do not use all the letters in a ring, color in all the spaces for unused letters. Each ring moving outward should begin in the spot after the last letter of the ring before it. See the practice code activity for an example if you need it.

If you can, trade your code with someone else. Were they able to solve your code? Were you able to solve theirs? Make any corrections if needed.

Do you have a different parachute design you can imagine? Feel free to design your own!

Decimal Number	Letter	What It Looks Like	Binary Number
1	A		0000001
2	B		0000010
3	C		0000011
4	D		0000100
5	E		0000101
6	F		0000110
7	G		0000111
8	H		0001000
9	I		0001001
10	J		0001010
11	K		0001011
12	L		0001100
13	M		0001101
14	N		0001110
15	O		0001111
16	P		0010000
17	Q		0010001
18	R		0010010
19	S		0010011
20	T		0010100
21	U		0010101
22	V		0010110
23	W		0010111
24	X		0011000
25	Y		0011001
26	Z		0011010

Answer for the hidden code on page 5: "Making dreams take flight"



BACKGROUND INFORMATION

Parachutes have been used since at least the 1700s. In 1797 Andrew Garnerin performed the first recorded parachute jump. His parachute, when opened, had a canopy that resembled a huge umbrella.

Since then, parachutes have been used by skydivers, on aircraft, on the Space Shuttle, and to slow the descent of rovers landing on the surface of Mars. Different uses of parachutes require different shapes and features that allow them to perform their task. When it comes to using parachutes for a Martian landing for example, the parachute needs to be able to function at supersonic speeds, or faster than the speed of sound. As you can imagine, more speed means it needs to slow down more force. In addition, the atmosphere on Mars is very thin compared to Earth's atmosphere, so parachutes need to be larger for use on Mars. Earth's atmosphere is about 100 times as dense as Mars' atmosphere.

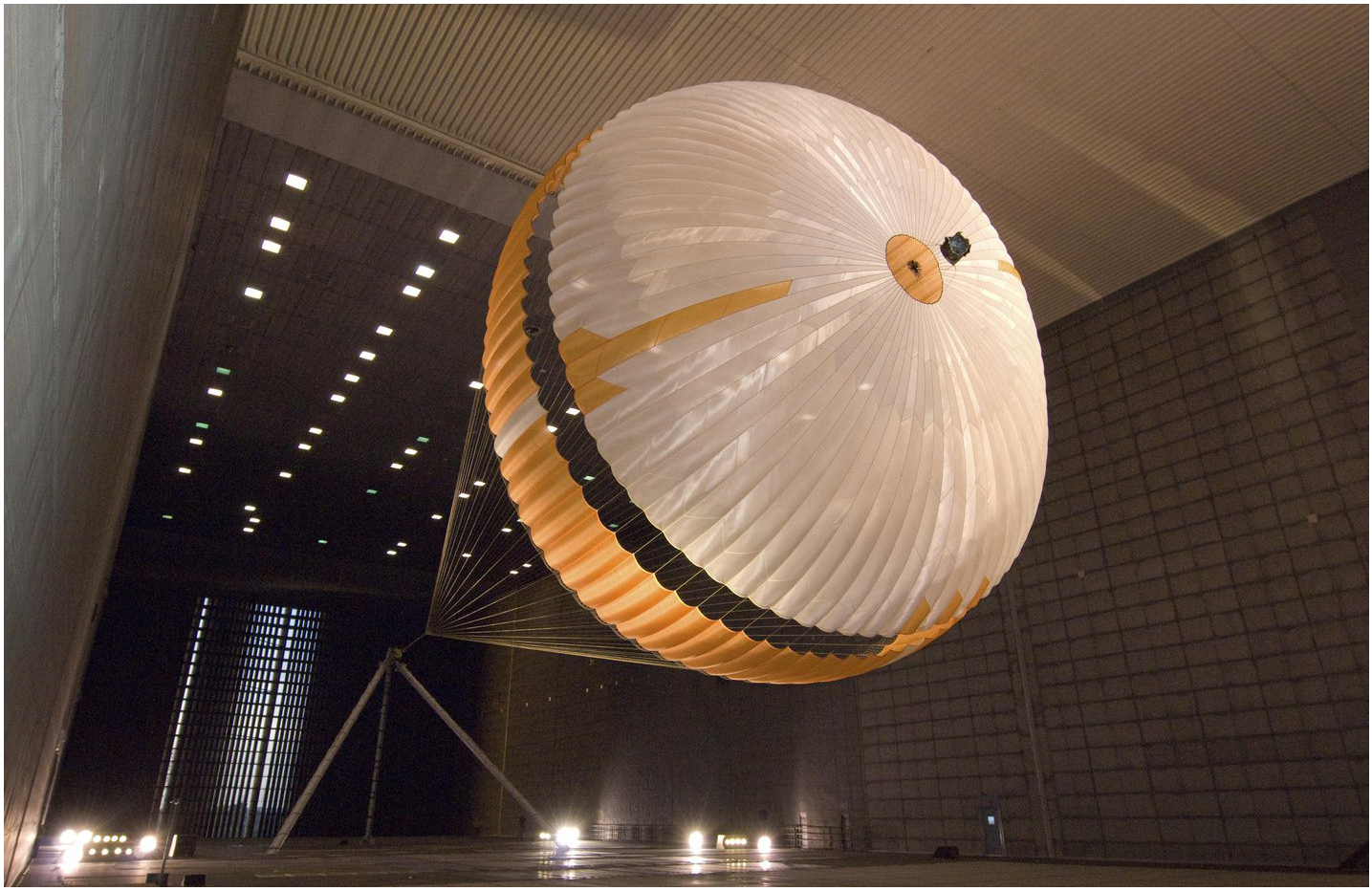


Figure 6- Credit: NASA/JPL-Cal Tech

To prepare for the Mars 2020 rover landing, NASA conducted the Advanced Supersonic Parachute Inflation Research (ASPIRE) project. ASPIRE evaluated two different parachutes that had to withstand 67,000 pounds of force during testing. Figure 6 shows one of the parachutes being tested in a wind tunnel at NASA Ames Research Center in Moffett Field, CA.

Before the mission to Mars, John McNamee, project manager of Mars 2020 at JPL, stated, “Mars 2020 will be carrying the heaviest payload yet to the surface of Mars, and like all our prior Mars missions, we only have one parachute and it has to work.” And it worked!

Figure 7- A parachute can deploy from a small airplane, allowing it to land safely even if its engine fails.

NASA has a history of aviation research that goes back more than a century. With its many aeronautical laboratories and wind tunnels, NASA has the tools to examine every facet of flight. This includes studying parachutes, like those used on spacecraft such as the Space Shuttle and Mars rovers like Curiosity and Perseverance.

In the images above, you can see work NASA has done to help develop a parachute that can be deployed in emergency situations with smaller aircraft. The NASA Small Aircraft Transportation System (SATS) was developed in the early 2000s. The technology was shared with BRS Aerospace, Inc, which developed a parachute system that deploys in less than 1 second, and has saved hundreds of small aircraft, their pilots, and passengers. The parachute systems are now standard equipment on Cirrus aircraft.

To find out more about NASA’s tests with subsonic and supersonic parachutes, take a look at these links:

Low Density Supersonic Decelerators: https://www.nasa.gov/pdf/737628main_Final_LDSD_Fact_Sheet_3-26-13.pdf

Mars 2020 Supersonic Parachute Test: https://www.nasa.gov/feature/jpl/nasas-mars-2020-mission-performs-first-supersonic-parachute-test

NASA ASPIRE parachute test: https://www.nasa.gov/feature/jpl/third-aspire-test-confirms-mars-2020-parachute-a-go

Parachutes for entire planes: https://www.nasa.gov/offices/oct/home/tech_life_brs.html

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