The United States Marine Corps, since its formation in 1775, has used STEM (Science, Technology, Engineering, and Math) concepts to become a force in readiness. The activities in this worksheet illustrate how Marines have applied STEM to aid them in meeting the variables of the battlefield throughout their history.

Following the numbers on the floorplan below, find these STEM activities in the galleries of the National Museum of the Marine Corps!
1. A Few Good Recruits
   - The U.S. Marine Corps has two different Recruit Training Depots, where recruits go to become Marines: Parris Island, South Carolina, and San Diego, California.

   If you are driving the 2,426 miles between Parris Island, SC, (A), and San Diego, CA, (B) at a speed of 60 miles per hour, how many hours would it take you to reach your destination?

   $\frac{2,426 \text{ miles}}{60 \text{ miles/hour}} = 40.43 \text{ hours}$

2. Marksmanship
   - The ability to hit a target with a rifle at ranges up to 500 yards is essential to being a Marine.
   - When shooting at a target, Marines must consider possible variables that could affect their shot. The two biggest variables that affect a projectile's flight are wind and gravity. Marines need to consider how much gravity will pull the bullet down after it is released. To read the wind’s direction and strength, Marines can use indicators like smoke or blowing leaves to help them.

   If the blue projectile hit a target 200 yards away, why did the green projectile not hit the same target?

   The green projectile does not have a great enough angle to hit the target 200 yards away and compensate for wind and gravity effects on the trajectory.
3. Smooth-Bore and Rifled Musket
   • Learn about Colonial gun technology. Touch the gun barrels and watch the videos.

   What new technologies were used to make guns more accurate?
   New technologies in a rifle: spiraling lands and grooves down the barrel of a rifle; conical-shaped bullet with a soft base, which would melt into the grooves and spin the bullet so that it traveled longer and faster.

4. Pacific Expeditions
   • Between the Revolutionary War and the Civil War, Marines sailed all over the world with the U.S. Navy on distant expeditions. One of the ships that sailed in the famous Wilkes Expedition was the USS Vincennes. This ship was a “sloop-of-war,” or warship, and was powered by wind.
   • The force of wind on the sails of a ship can change both its direction and speed. Wind comes from the uneven heating of the earth’s surface. Hotter air rises, and then colder air sinks down and replaces it. This movement is what makes the wind blow.

   Why do you think there are both cold winds and warm winds?
   Cold air sinks and warm air rises causing both cold and warm winds. These winds are constantly blowing over the surface of the earth.

   To learn more about winds and weather, visit: http://www.noaa.gov/

5. Command and Communications
   • Instruments were used during the Civil War for communicating combat actions.
   • Field drums were used to signal field maneuvers in battle and control daily routine activities in camp. The sound of a drum can be heard because of the sound waves it sends out.
   • In this image, the different lines show different sound waves, or sinusoidal waves, at various frequencies and wavelengths. Frequency is defined as the number of reoccurrences of a repeating events over a certain amount of time.

   Wavelength is the spatial distance of one complete wave.

   Which sound wave has the greatest frequency?
   Which has the largest wavelength?
   Greatest frequency: Purple wave
   Largest wavelength: Red wave
Global Expeditionary Force: 1866-1916

6. Technology

- During the Industrial Revolution, steam-powered ships were one of the inventions that drastically changed how far and how quickly Marines could travel. U.S. Marines were aboard President Roosevelt’s “Great White Fleet,” which was a group of **steam-powered ships** sent around the world to display America’s power.
- These ships had boilers that made steam by boiling water. **Energy** was used to turn the water into steam. The steam then gave off energy before turning back to a liquid. This energy is considered the “usable” energy of steam, which powered steam ships. The process of powering steam ships is a repeating circular system.

In this diagram, describe what is going on at each of the numbered steps.

1. Water running through tube to pump.
2. Boiler heating up water.
3. The water has turned into steam. When the steam begins to turn back into water, it will give off energy that powers the engine.
4. Steam turns back into water, and heat is released as the steam condenses.

7. Marine Life: Philippines, 1901

- A dry **tent** was one of the small pleasures in which Marines in the Philippines could take comfort. To keep the Marines sheltered, the tents had to be constructed properly.

Step inside this tent and describe the steps needed to construct a tent like this so that it would provide the best shelter possible.

1. Secure poles in the ground vertically.
2. Hang guy line from the top of the poles, or place a post horizontal on top of the poles.
3. Hang tent fabric from guy line or the horizontal post.
4. Secure tent fabric to vertical poles and/or to the ground with stakes.
8. Field Heliograph

- The field heliograph reflected the sun’s rays with a **mirror**, and a spring-activated shutter could be opened and closed to transmit Morse code messages to a receiving station located 30 or more miles away.
- Mirrors reflect light at an **angle** equal to that in which the light comes in.

If a Marine field heliograph operator sent a message to a receiving station with an Angle of Incidence of 45°, what would be the Angle of Reflection?

The Angle of Reflection would be 45°

9. King Armored Car

- The King armored car was the first American **armored vehicle** and was acquired by the U.S. Marine Corps in 1916. The King armored car was built on top of a King luxury sedan chassis car. This armored car was covered with quarter-inch-thick armor that was placed in sections over the car.
- If you look closely at the armor on the left side of this car, you can see a small **dent** about the size of a bullet. This mark is from the testing of the car’s armor to see if it could be penetrated.

Why do you think that it is important that engineers test their products before they are used?

*Product testing is important because it assures that the product meets the required specifications and will not malfunction or be below the standards.*
10. Chemical Warfare

- Chemicals and gases were commonly used weapons during World War I. Mustard gas was especially dangerous. It acquired the name “mustard gas” because when the gas was used in an impure form, which was more common, the gas had a yellow-brown color and had an odor that resembled the smell of mustard or garlic.
- The molecular formula of mustard gas, also called sulfur mustard, is C₄H₈Cl₂S.

Using the atomic masses below, find the formula mass of sulfur mustard.

C (Carbon) = 12.01, H (Hydrogen) = 1.008, Cl (Chlorine) = 35.45, S (Sulfur) = 32.07

\[
\begin{align*}
C_4H_8Cl_2S &= (12.01)_4 + (1.008)_8 + (35.35)_2 + (32.07) \\
&= (12.01 \times 4) + (1.008 \times 8) + (35.35 \times 2) + (32.07) \\
&= 48.04 + 8.064 + 70.7 + 32.07 = 158.874 = \text{the formula mass of sulfur mustard}
\end{align*}
\]

11. Liberty L-12 Aircraft Engine

- This engine was designed during the heat of war and was perhaps America’s greatest material contribution to the Allied victory in World War I. The Liberty L-12 engine powered thousands of British, French, and Italian aircraft. This engine had an internal combustion engine.

The Steps of an Internal Combustion Engine

At which two steps does an internal combustion engine generate its power?
Ignition of fuel, Power stroke
12. Pearl Harbor

- When Japanese forces attacked U.S. forces at Pearl Harbor, Hawaii, in 1941, many people across the U.S. found out the news by listening to their radios. Radio newscasts were one of the important ways people learned about what was going on in the world during that time.
  
- The first radio stations were AM stations. FM radio was invented in the 1940s but didn’t become commonly used until the 1970s. AM stands for “amplitude modulation,” and FM stands for “frequency modulation.” AM radio works by changing the amplitude (strength) of the broadcasted signal. FM works by changing the frequency (repetition) of the signal instead of the strength.

AM radio stations have more interference in their signals than FM stations. What kind of sources do you think would create the interference that sounds like static on the radio? Interference can be caused by many things: sparks discharging when a car is started, motors running in electrical appliances, and lightning.

13. Ford GPW Jeep

- In 1941, the word “Jeep” became a part of the American lexicon. Jeeps like this one were used by the Marine Corps throughout World War II.
- The table below gives different measurements of this Ford Jeep.

<table>
<thead>
<tr>
<th>COMBAT WEIGHT</th>
<th>LENGTH</th>
<th>HEIGHT</th>
<th>WIDTH</th>
<th>MAX SPEED</th>
<th>CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,800 pounds</td>
<td>11 ft</td>
<td>6.3 ft</td>
<td>5 ft</td>
<td>65 mph</td>
<td>17 gal</td>
</tr>
<tr>
<td>1,272.7 kg</td>
<td>3.35 m</td>
<td>1.92 m</td>
<td>1.52 m</td>
<td>68.9 kph</td>
<td>64.43 L</td>
</tr>
</tbody>
</table>

- While the **Standard system** (inch, gallon, ounce, etc.) is used in the United States, in other parts of the world, like the United Kingdom, the **Metric system** (centimeter, liter, gram, etc.) is used.

Use the following conversions to convert the measurements in the first row of this table into metric measurements. Place your answers in the blank spaces in the second row of the table.

- 1 kilogram = 2.2 pounds
- 1.06 kilometers per hour = 1 mile per hour
- 1 meter = 3. 28 feet
- 3.79 liters = 1 gallon

1 kg
\[
2,800 \text{ lbs} \times \frac{1 \text{ kg}}{2.2 \text{ lbs}} = 1,272.7 \text{ kg}
\]

1 mile per hour
\[
65 \text{ mph} \times \frac{1.06 \text{ kph}}{1 \text{ mph}} = 68.9 \text{ kph}
\]

1 foot
\[
5 \text{ ft} \times \frac{1 \text{ m}}{3.28 \text{ m}} = 1.52 \text{ m}
\]

1 gallon
\[
17 \text{ gal} \times \frac{3.79 \text{ L}}{1 \text{ gal}} = 64.43 \text{ L}
\]
14. Speed Graphic Camera

- In the Battle of Iwo Jima during World War II, photographer Joe Rosenthal used the Anniversary Speed Graphic camera to photograph the second flag-raising over Mt. Suribachi. The camera worked by recording the visible light that is reflected from objects in a single moment in time.
- Humans are only able to see a small part (the **visible** light) of the **electromagnetic spectrum** that comes from the sun. A camera works similar to the way the human eye does by detecting the **visible** light.

**The Electromagnetic Spectrum**

Although the human eye cannot see the invisible portions of the electromagnetic spectrum, can you name some of the devices we have invented to detect those measures?

The radio, the microwave, X-Ray machines
**Korean War (Send in the Marines): 1946-1953**

15. **3.5-inch Rocket Launcher “Super Bazooka”**
   - This rocket launcher could launch a rocket 900 yards, and the rocket could penetrate 11 inches of armor.
   - Newton’s Second Law of Motion: Force equals mass times acceleration (\(F = MA\)).
   - The connection between the rocket launcher and Newton’s Second Law: The force (\(F\)) of a launched rocket is the product of that rocket’s mass (\(M\)) and acceleration (\(A\)) multiplied together. \(F = MA\).

   If the acceleration of a launched rocket from a 3.5-inch rocket launcher is 20.6 meters/second squared (\(m/s^2\)) and the mass is 4 kilograms, what is the force of the rocket?

   \[
   F = MA \\
   F = (4 \text{ kg}) \times (20.6 \text{ m/s}^2) \\
   F = 82.4 \text{ Newtons}
   \]

16. **LVT3**
   - This vehicle is an **amphibious tractor** that has the ability to travel over the water and then come up on land and carry its cargo over beaches. These large and heavy vehicles are able to stay afloat in water because of a force called buoyancy.
   
   - **Buoyancy** is an upward force that pushes against the weight of an object that is immersed in a fluid. Archimedes' principle states: Any object, wholly or partially immersed in a fluid, is buoyed up by a force equal to the weight of the fluid displaced by the object.

   How would this LVT, which has a combat weight of 14.8 tons, float?
   It would float because the force of buoyancy would push up against the LVT in an equal amount that gravity is pushing the LVT into the water.

17. **Main Line of Resistance (MLR) Field Telephone**
   - The fortified trench lines of the Korean War, in its final years, allowed the US Marines to stay inside shelters for long periods of time. Field telephones, like the one inside this bunker, were used to communicate with others without having to leave the shelter.
   
   - The field telephone was a way of signaling the operator, or another party, that you wanted to make a call, or talk to them. The field telephone operator would use a **hand crank** to generate **electricity**, which would then **ring** the bell on the field phone the user was trying to contact.

   Why does a hand crank generate electricity?
   The energy that used to turn the hand crank is converted into electricity because the First Law of Thermodynamics says energy cannot be created or destroyed, only converted from one form to another.
18. Bell UH-1E Iroquois (Huey)

- Helicopters were used extensively during the Vietnam War. A U.S. Marine flew the Huey helicopter hanging above your head during the Vietnam War.
- The **propellers (rotor blades)** on a helicopter are **curved** so that they create **lift** when they spin. The rotor blades of a helicopter are like the wings of an airplane. Air moves faster at the top of the spinning curved blade so slower air underneath is at a higher pressure and pushes up on the blade, which causes the helicopter to rise.

Do scientists consider air a fluid? Explain why or why not.
Yes, scientists consider air a fluid. A fluid is any substance with molecules that move around freely, which includes both liquids and gases (like air).

19. Navy Medical Support

- **Navy Corpsmen** who tended wounded Marines belonged to the Navy Hospital Corps. Marines called them “Angels of Mercy.”
- Navy Corpsmen were trained to be able to perform as **doctors** and treat those who are wounded in the field. Navy Corpsmen need to understand the human body and its **skeletal system**.

Place these names of the skeletal system next to their appropriate location on the skeleton.

- Collarbone
- Skull
- Femur
- Humerus
- Tibia
- Vertebrae

Skull
Collarbone
Humerus
Vertebrae
Femur
Tibia