IMHOTEP'S LEGACY ACADEMY

6.4 PROPULSION

Grade 6 Activity Plan

Reviews and Updates

6.4 Propulsion

Objectives:

1. Describe and demonstrate different means of propulsion.
2. Introduce students to Newton's third law.

Keywords/concepts: Propulsion, pressure, turbine, fluid, Newton's third law, engine, thrust, energy, force

Curriculum outcomes: 106-3, 107-9, 204-7, 205-5, 206-6, 301-17, 303-34.

Take-home product: Balloon rocket, rubber band boat

Segment	Details
African Proverb (5 min.)	"Even as the archer loves the arrow that flies, so too he loves the bow that remains constant in his hands." **Nigeria**
Pre-test (10 min.)	Each student is given a rubber band and asked to fling it across the room. Why did the rubber band fly across the room? Have students brainstorm why the rubber band does this. Introduce propulsion.
Background (10 min.)	What is propulsion? How do we use propulsion? Who was Newton?
Activity 1 (15 min.)	Students demonstrate propulsion using air pressure by making a balloon rocket.
Demo 1 (5 min.)	Show video on Hero's engine: https://www.youtube.com/watch?v=l8gGuhj8NBY Propulsion using water is demonstrated using a spinning water rocket.
Activity 2 (20 min.)	Students demonstrate mechanical propulsion by making a rubber band powered paddleboat.
Activity 3 (20 min.)	Students make a turbine using an aluminium plate and tea lights.
Post-test (10 min.)	Word search

Suggested interpretation of the proverb:
The archer can't use the bow without the arrow, the two are important to him in order to achieve his target. The bow is just as important as the arrow that flies because the bow is what gives the arrow the necessary force to go a long distance. In today's activity, you will discover the two important things required to drive an object forward.

Background Information

Propulsion

Propulsion means to push forward or drive an object forward. A propulsion system is a machine that produces thrust to push an object forward. On airplanes, thrust is usually generated through some application of Newton's third law of action and reaction. The engine accelerates a gas, or working fluid and the reaction to this acceleration produces a force on the engine.

Newton's third law

For every action, there is an equal and opposite reaction. Forces are found in pairs. Think about the time you sit in a chair. Your body exerts a force downward and that chair needs to exert an equal force upward or the chair will collapse. It's an issue of symmetry. Acting forces encounter other forces in the opposite direction. There's also the example of shooting a cannonball. When the cannonball is fired through the air (by the explosion), the cannon is pushed backward. The force pushing the ball out was equal to the force pushing the cannon back, but the effect on the cannon is less noticeable because it has a much larger mass. That example is similar to the kick when a gun fires a bullet forward.

Sir Isaac Newton (1642-1727)

Newton was an English natural philosopher, generally regarded as the most original and influential theorist in the history of science. In addition to his invention of the infinitesimal calculus and a new theory of light and color, Newton transformed the structure of physical science with his three laws of motion and the law of universal gravitation. As the keystone of the scientific revolution of the 17th century, Newton's work combined the contributions of Copernicus, Kepler, Galileo, Descartes, and others into a new and powerful synthesis. Three centuries later the resulting structure - classical mechanics - continues to be a useful but no less elegant monument to his genius.

Gas turbine propulsion

During World War II, a new type of airplane engine was developed; this engine was called a gas turbine engine. We sometimes call this engine a jet engine. Early gas turbine engines worked much like a rocket engine creating a hot exhaust gas, which was passed through a nozzle to produce thrust. But unlike the rocket engine, which must carry its oxygen for combustion, the turbine engine gets its oxygen from the surrounding air. A turbine engine does not work in outer space because there is no surrounding air. For a gas turbine engine, the accelerated gas, or

working fluid, is the jet exhaust. Most of the mass of the jet exhaust comes from the surrounding atmosphere.

(Optional for advanced students) Newton's first and second laws

First law:

The first law says that an object at rest tends to stay at rest, and an object in motion tends to stay in motion, with the same direction and speed. Motion (or lack of motion) cannot change without unbalanced force acting. If nothing is happening to you, and nothing does happen, you will never go anywhere. If you're going in a specific direction, unless something happens to you, you will always go in that direction. Forever.

This law is often called: "the law of inertia".

Second law:

F=ma (Force=mass x acceleration)

Acceleration is produced when a force acts on a mass. The greater the mass (of the object being accelerated) the greater the amount of force needed (to accelerate the object).

Activity 1: Balloon Rocket

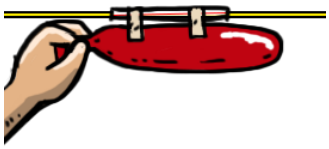
Purpose: To introduce Newton's third law and it's connection to propulsion and thrust.

Item	**Quantity (10 students)**
Balloon (round ones will work, but the longer "airship" balloons work best)	10
Kite string (3 meters)	30 meters
Plastic straw	10
Tape	1 roll

Procedure:

1) Tie one end of the string to a chair, doorknob, or other support.
2) Put the other end of the string through the straw.

3) Pull the string tight and tie it to another support in the room.
4) Blow up the balloon (but don't tie it.) Pinch the end of the balloon and tape the balloon to the straw as shown below. You're ready for launch



5) Let go and watch the rocket fly!

The Science:

As the air rushes out of the balloon, it creates a forward motion called THRUST. Thrust is a pushing force created by energy. In the balloon experiment, our thrust comes from the energy of the balloon forcing the air out.

A balloon provides a simple example of how a rocket engine works. The air trapped inside the balloon pushes out the open end, causing the balloon to move forward. The force of the air escaping is the "action"; the movement of the balloon forward is the "reaction" predicted by Newton's Third Law of Motion.

The distance that a balloon will travel when restricted to a straight line is related to the amount of air trapped inside the balloon when it is released. Similarly, the distance a rocket will travel is related to the amount of fuel trapped inside the rocket engine and the properties of that fuel.

Demo 1: Spinning Water Rocket

Purpose: To show how differences in pressure are capable of producing rotational motion.
Suggested format: Do this activity in one big group to minimize the potential for water spillage.

Item	**Quantity (10 students)**
Empty Pop bottle	1
Bendy straws	2
Glue gun	1
Water	2 Litres
Drill	1
Screw	1
7.5mm drill bit	1
Ring stand	1
Large plastic container	1
String	1 roll

Procedure:
TO BE DONE BY MENTOR PRIOR TO ACTIVITY:

1. Place a 7.5mm drill bit onto a drill and secure it tightly in place
2. Mark a point on the pop bottle that is ¼ of it's length up from the bottom, mark a point with the same length on the opposite side of the bottle
3. Take the drill and drill a hole inside the bottle at the marked point on both sides.
4. Drill a small pilot hole into the top of the bottle (where the cap screws on) and then use the screwdriver setting on the drill to insert the screw across the top of the bottle.
5. Tie the string onto the screw so that it is centered.
6. Cut the bendy straw so that there is an equal amount of straw on both sides of the bend.
7. Place a bendy straw through both pop bottle holes, glue the straws in place to ensure a tight fit and so water will not leak out.
8. Stretch out the accordion section of each straw to provide greater length and bend both straws so that they make an inverse (L) shape in relation to the hole in the pop bottle. They should be pointing in opposite directions.

At the school site:

9) Play video on Hero's engine: https://www.youtube.com/watch?v=I8gGuhj8NBY

10) Tie the bottle to the stand so it can move freely and place the container under it.
11) Have someone hold the bottle so it can't spin and pinch the ends of the straws so they can't leak.
12) Fill the bottle with water then let go. The bottle should spin as it empties through the straws.

The Science:

The water, while flowing out of the bottle exerts a pressure on it in the backward direction. This is in accordance with Newton's third law. Water contained in the bottle pushes on the water at the opening of the straws, which makes water come out of the straws. As a reaction to this, the outflowing water pushes the water in the straw backward. As the straws are in an L shape the force being exerted as the water flows out pushes perpendicular to the bottle. The forces acting on the two straws will rotate the bottle in the same direction and so the bottle starts spinning.

Activity 2: Rubber Band Boat

Purpose: To demonstrate an alternate method of propulsion and to demonstrate Newton's third law.

Item	**Quantity (10 students)**
Piece of foam core board (10cm x 15cm)	10
Scissors	10
Ruler	10
Pencil	10
Tub of water to test boat	1

Procedure:

1) **TO BE DONE BY MENTOR PRIOR TO ACTIVITY:** Cut out a piece of board 10 centimeters wide and 15 centimeters long
2) Cut off the corners and create a pointed front hull to taper the front of your boat (the opposite end is the back of your boat)
3) Cut a slot for the paddle in the center back that is 4 centimeters wide and 5 centimeters long
4) Using the piece cut out of the back of the boat, create paddles that are 2.5 centimeters wide and 4 centimeters long by cutting it in half.
5) Cut a slot in the center of one long side of each piece
6) Slide the two pieces together to form a cross (This is the paddle for your boat)
7) Put a rubber band between two blades of the paddle
8) Hold the paddle in the slot at the back of the boat and slide the ends of the rubber band over the left and right sides of the back
9) Twirl the paddle to twist the rubber band
10) Place your boat in water and watch the paddle propel the boat over the water.

The Science:

Propulsion systems need a source of stored energy. In this case the energy came from you when you wound up the paddle and was stored in the rubber band. You got the energy from food, which got its energy form the sun. The boat is propelled in a method similar to "Demo 1" the paddle pushed on the water and the water pushed back in the opposite direction propelling the boat forwards (Newton's third law).

Activity 3: Gas Turbine

Purpose: To demonstrate an alternate method of propulsion and introduce turbines.

Suggested format: Students work in pairs

Item	**Quantity (10 students)**
Aluminum pie tin	5
Scissors	5
Protractor	5
Ruler	5
Compass (optional)	5
Pin	5
3in length of 1/8in dowel	5
Tape	1 roll
Medium sized bead	5
Thread reel	5
Plasticine	1 small pack
Plate	5
Candles (tealights)	20
Lighter or matches	1 box/ 1 lighter

Procedure:

1) Using scissors cut out the bottom of a large aluminum pie tin as evenly as possible. Make a small hole in the center with the point of the compass.

2) Mark a smaller circle in the center. Use a protector to mark 16 equal sections of 22.5 degrees, and cut along each one to the inner circle. Use one scissor cut along each line, if possible.

3) Angle the blades by holding the inner tip and twisting the outer edges 20 to 30 degrees. The center of the inner tip should be flat, in line with the center of the disk.

4) Tape the blunt end of the pin to one end of the dowel. Finish it off neatly and trim if necessary. Place the bead on the pin. This will allow the finished turbine to spin freely.

5) Put the dowel in the reel into the modeling material in the center of the plate. Place the four candles on the plate around the reel.

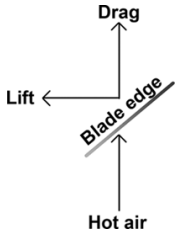
6) Place the hole in the center of the turbine over the pin

7) **TO BE DONE BY MENTOR:** Light the candles. The hot air from the candles should spin the turbine.

The Science:

The candle's flame heats up the air above the candle. Heat is a form of *energy*, and it makes the air right above the candle rise above the colder air around it. This rising hot air pushes up against the blade above it. Because the blade is tilted, this push causes the blade to move sideways (to the right or left, depending on how the blade is tilted), and spin around the shaft. Each blade that moves above the flame also gets "pushed" by the hot air.

The rising hot air exerts a *force* on the blade, which makes it move. A force is something that pushes or pulls on something else. The force that moves the blade sideways is called lift. Normally, we think of lift as an upward force, such as with flying airplanes. However, for an airplane, air is coming toward the airplane from straight in front of it, whereas with a blade on the candle carousel, the air is going upwards, hitting the blade from below. Because lift is defined relative to which way the air is going, in a candle carousel the lift is a sideways force. Another force acting on each blade is the force of drag, which pushes upward against the blade, in the same direction as the moving air. The picture below shows a diagram of how the hot air and forces of lift and drag act on a candle carousel's blade to make it move. To relate this to Newton's third law the action of the hot air exerting a force (pushing) on the blade of the turbine gives the reaction of the blade moving.



REFERENCES

Background:
https://www.grc.nasa.gov/www/k-12/airplane/bgp.html
http://teachertech.rice.edu/Participants/louviere/Newton/
http://www.physics4kids.com/files/motion_laws.html
http://users.clas.ufl.edu/ufhatch/pages/01-Courses/current-courses/08sr-newton.htm?utm_source=lasindias.info/blog
Useful link:
https://www.nasa.gov/sites/default/files/atoms/files/rockets_away_k-12.pdf

Activity 1: Balloon Rocket
http://sciencebob.com/make-a-balloon-rocket/
http://exploration.grc.nasa.gov/education/rocket/BottleRocket/Shari/propulsion_act.htm

Demo 1: Spinning Water Rocket
https://www.youtube.com/watch?v=ifVILqnvXuE
http://www.vigyanprasar.gov.in/activity_based_science/Exp9.htm

Activity 2: Rubber Band Boat
http://www.letstalkscience.ca/programs-resources/activities/item/how-can-we-make-a-paddle-boat.html
http://livingonthecheap.com/kids-crafts-make-a-rubber-band-powered-boat/
https://books.google.ca/books?id=B8D-_PqexDIC&pg=PA19&lpg=PA19&dq=propulsion+for+kids+rubber+band+boat&source=bl&ots=TD8L43hTk4&sig=lqMlqaOQkhyCx3NHZptQf2ud7wE&hl=en&sa=X&redir_esc=y#v=onepage&q=propulsion%20for%20kids%20rubber%20band%20boat&f=false

Activity 3: Gas Turbine
http://www.kidsgen.com/school_projects/jet_propulsion.htm
http://www.sciencebuddies.org/science-fair-projects/project_ideas/Aero_p051.shtml#background

Post Test

Print off the "Propulsion Word Search" worksheet on the following page.

Propulsion Word Search

V L Q P D N V P P D H R M A R B B G H Q
P K U K P L R P R H K A G Q R S C M B Y
F V K Y I E G W O U S E C R O F P Q L W
V K W V S S S J P G T B G Z S E F N H B
D B V S Z G X F U F M I N U P X P L H Y
A I U U X P Z K L P Z Q I L V J Q I D Q
E R U G K J W F S Q K R B P L H J N L H
E T S L S H N V I D C J Y C O D L M X T
U A I U F U Q V O R Q E H D W X E V C I
U N V S H T C Q N H N O I T C A E R Y U
K T A R O V P K R H X T E P U Y J G Y G
H E K R V P J S G T C Q O U D E R L C P
A N L P N W P C U D U X A S O E C M Y H
W I K M Y E R O G O F M C Z N Z H H X R
C B L S H D W X X R K I T E C D P J L G
E R T H R U S T O Z W J I T T Z Z L D U
W U Y M N Q D C O R Y Y O Y Q K T C L Y
Z T T P T J K Q D N Q J N C T B P Z L G
N Y V P A E W R G U W L B H Z K P R S Q
V M J S T J P Z H S T E Z E B M S J T X

Find the following words:

Action
Energy
Fluid
Forces
Newton
Opposite
Pressure
Propulsion
Reaction
Rocket
Thrust
Turbine