

# FORCES ON STRUCTURES AND MECHANISMS

## UNIT OVERVIEW

May the force be with you! Students study and experience forces, and how they relate to simple machines and structures in this fast-paced unit. Students build bridges, catapults and towers. They participate in meaningful activities associated with the theme of each lesson which are followed by related overhead notes. No need for textbooks or other reference material with this self-contained unit! The exciting format helps to keep student interest at its highest, rather than concentrating on the memorization of factual information. Optional activities add further flexibility to the unit, making it easy to use for the teacher. Students will learn to love science class.

## PART I - CORE TEACHING LESSONS

- |    |  |   |
|----|--|---|
| 1. | <b>What Is Force? Types Of Forces</b>    | Forces On Structures And Mechanisms Wordsearch      |
| 2. | <b>Gravity Force, Air Pressure</b>       | Gravity Force - Air Pressure Word Problems          |
| 3. | <b>Force Of Friction, Magnetic Force</b> | Science Friction                                    |
| 4. | <b>Tension And Compression</b>           | Tower Of Omelette                                   |
| 5. | <b>Forces And Machines</b>               | Rube Goldberg Silly Machine                         |
| 6. | <b>Forces And Levers</b>                 | Medieval Catapult                                   |
| 7. | <b>Forces And Pulleys</b>                | Homework For Teacher (Student Developed Experiment) |
| 8. | <b>Wheels, Axles And Gears</b>           | May The Force Be With You (Brainteasers)            |

## PART II - MAJOR PROJECT - BRIDGE BUILDING

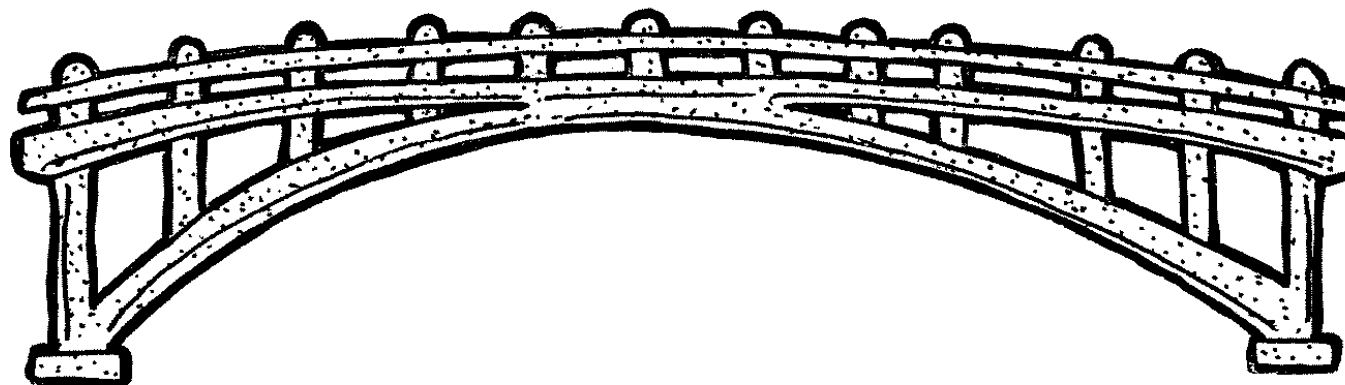
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|-----|--|--|
| 9.  | <b>Types Of Bridges (Beam Bridges)</b>   | Major Project - Bridge Building              |
| 10. | <b>Arch Bridges, Pontoon Bridges</b>     | Major Project - Bridge Building (Continued)  |
| 11. | <b>Suspension Bridges, Truss Bridges</b> | Major Project - Bridge Building (Continued)  |
| 12. | <b>Bridge Building Concerns</b>          | Major Project - Bridge Building (Completion) |

## PART III - STUDENT NOTES

Basic information and concepts are conveyed using the student notes. These notes can be put onto overhead transparencies, photocopied for the students, or simply written on the board for students to copy into their notebooks.

## PART IV - OPTIONAL ACTIVITIES

1. Forces On Structures And Mechanisms Crossword
2. Matching Review
3. Box or Tetrahedron Kite
4. Engineer In The Class
5. Pictograms
6. Bridge - The Card Game
7. Stomp Rockets
8. Lego Mania
9. Cantilever Bridge
10. Pyramids
11. World Trade Center Discussion





## GRAVITY FORCE AND AIR PRESSURE

NAME: \_\_\_\_\_

Instructions: Complete the following problems being sure to show your work. (Answer In Full Sentences where possible - A.I.F.S.)

- List four types of forces.
  - \_\_\_\_\_
  - \_\_\_\_\_
  - \_\_\_\_\_
  - \_\_\_\_\_


- Why is the force of gravity on Jupiter much higher than on earth? (A.I.F.S.)



- What is the force of gravity (in Newtons) of a bowling ball that has a mass of 3kg?

- What is the gravity force on a student with a mass of 45kg?






# HEAR YE! HEAR YE!

To all engineers in the Kingdom of DONUTLEVER:

His and Her ROYAL HIGHNESS, The KING AND QUEEN OF THE KINGDOM OF DONUTLEVER do hereby announce this official contest to build a catapult that will be used to batter down the castle walls of the evil and vile BLACK KNIGHT.

Instructions and Rules as follows:

- Use scissors to cut the cup as shown
- Make three holes in the cup as shown
- Attach the spoon to the wooden dowel with the small elastic
- Use tape to secure one end of the large elastic to the end of the spoon
- Put the other end of the elastic through the hole near the bottom of the cup
- Place the small piece of popsicle stick through the elastic to keep it from slipping back through
- Place the dowel in the holes and you are finished
- Practice aiming the catapult. The distance will be 3 meters
- Increase tension on the elastic by turning the popsicle stick
- Three and only three attempts will be made to destroy the castle of the Black Knight with one point awarded for each block of the castle wall that is knocked out of place and five points awarded for knocking over the Black Knight himself.



Good Luck!

## HOMEWORK FOR TEACHER - GUIDELINES

NAME: \_\_\_\_\_

### Instructions:

- Your job is to devise an experiment for your teacher that will help the teacher understand the three types of pulley set-ups shown below. Your experiment should have a way of helping the teacher learn which pulley set-up moves the load with the least (and most) amount of effort.



Single Fixed Pulley

Moveable Pulley

Block And Tackle

- Your experiment should ask the teacher to explain what the purpose of the experiment is.
- Your experiment should have instructions on how to set up the apparatus and how it should be used. (A diagram might be useful.)
- Your experiment should describe some way of testing which setup requires the most and least effort. (A scale to weigh fish might come in handy.)



- Your experiment should ask the teacher questions about the experiment and what was learned. (Don't make the questions too easy or too difficult.)
- Your experiment should fit onto a one page worksheet.

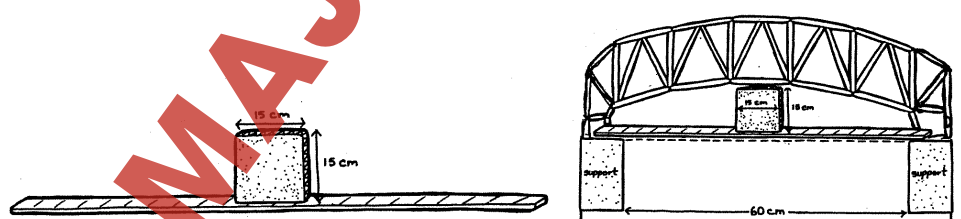
## LESSON #9 - MAJOR PROJECT - BRIDGE BUILDING (Types Of Bridges, Beam Bridges)

### Student Objectives and Activities

- Students review a brief history of bridge building. Students learn about the types of bridges and complete notes on Simple Beam Bridges.
- Students are introduced to the major project in which they build a bridge out of popsicle sticks. Students begin planning the bridges.

### Suggested Teaching Strategies

- Begin the lesson by explaining to the students that they will begin a major project, "Bridge Building Activity".
- Students complete brief notes outlining a history of bridge building, types of bridges and Simple Beam Bridges. (The format for most of the classes will be the same. Students first complete notes relating to bridges with the remaining time designated for the planning and construction of the bridge. The bridge building project is best if spread over a few classes allowing time for the glue to dry as each section of the bridge is built.)
- Divide students into groups of three (or two) beforehand, being sure the group members are capable of working together.
- Distribute the "Bridge Building Guidelines" sheets and go over them carefully.
- Students first draw a rough plan of their bridge on the sheet provided. (Students are not required to stick to their plan but it is a good process to go through to help give them direction.)
- Bridges can be any style, with arch or beam bridges being the most common as long as they meet the criteria in the guidelines. (As a variation, teachers may choose to restrict all bridges to one particular type such as "arch" or "beam".)
- Beforehand, glue or tape a 15cm by 15cm piece of cardboard to the center of a meterstick. The cardboard should stand vertically and will serve as the template which must pass under the center of each bridge without touching. (This template rule stops students from simply gluing the sticks together to form a single, laminated piece of wood which is nearly indestructible!)



### \*\*\* Note \*\*\*

Due to time restrictions, teachers may choose to do the bridge building activity as a separate section, apart from the first eight lessons. It makes a dandy, week-long project that kids really get into. Because students become so self-motivated, this project is especially suitable for those weeks before major holidays.

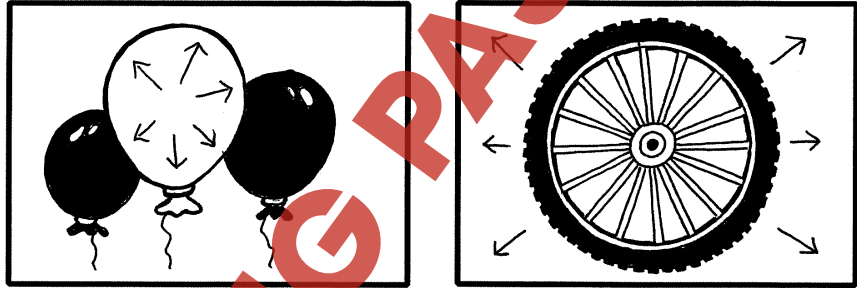


**Air Pressure - Force Of Air**

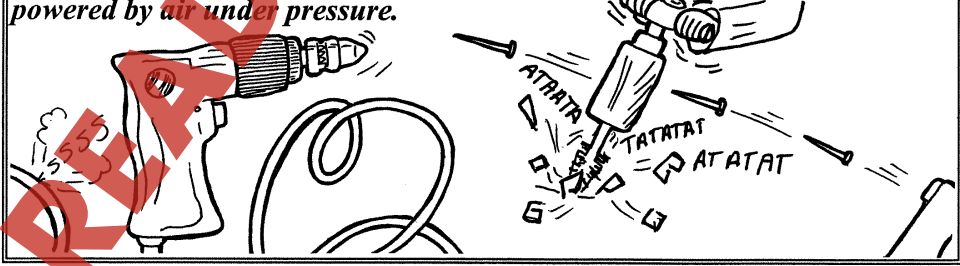
Air is a gas and like all types of matter, it has a mass. This mass pushing down on a person creates a force called air pressure. Imagine what it would feel like to lift a column of air as high as the sky. That is air pressure.



The air inside a balloon pushing outwards or a bike tire that has been pumped up are both examples of air pressure.

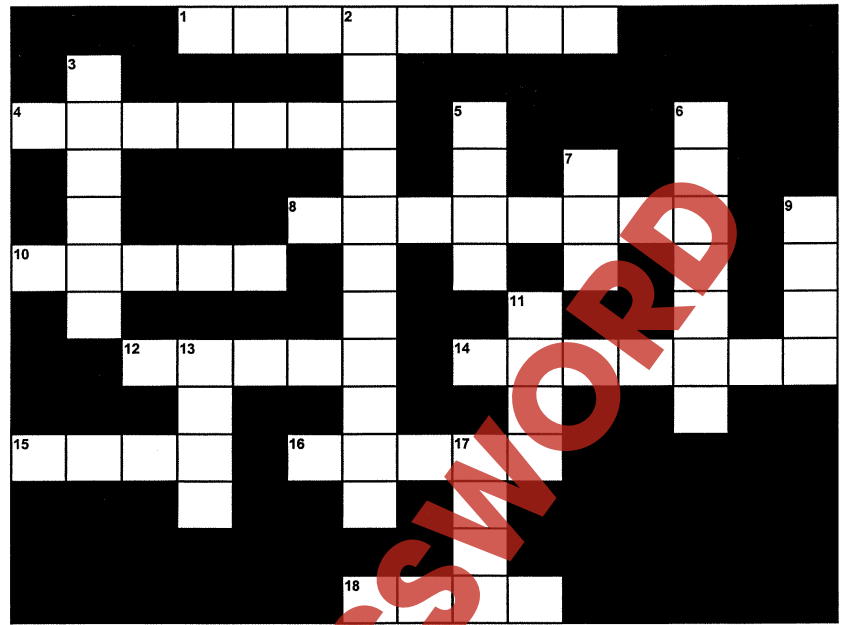


**Factfile:** Air under high pressure is commonly used to operate all kinds of tools. Mechanics in garages use compressed air drills and wrenches, roofers use air-operated nail guns, while city workers use jack-hammers powered by air under pressure.



**FORCES ON STRUCTURES AND MECHANISMS**

NAME: \_\_\_\_\_



**CLUES**

**Across**

- 1. A mixture of sand, gravel, water and cement. (Gangsters make galoshes for people out of this building material)
- 4. Move this close to the load to make the work easier.
- 8. Always works to slow something down.
- 10. A simple machine - with three types.
- 12. Used as a support in bridges and buildings.
- 14. Temporary bridges made by the army are often this type.
- 15. The most simple type of bridge.
- 16. A push or a pull.
- 18. A force is a \_\_\_\_\_ or a pull.

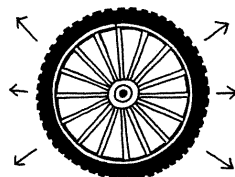
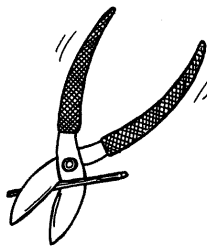
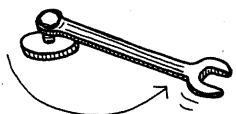
**Down**

- 2. When a force squeezes an object - the opposite of tension.
- 3. A simple machine used to hoist objects.
- 5. Ronald McDonald uses this design in his advertising - the Romans used it too.
- 6. When an object is being pulled.
- 7. \_\_\_\_\_ pressure. Used to operate nail guns, wrenches and jackhammers.
- 9. Gravity force here is only one sixth as strong as on the Earth.
- 11. Used to carry tension forces.
- 13. Another word for inclined plane - a type of simple machine.
- 17. Another word for teeth on a gear.

**FORCES ON STRUCTURES AND MECHANISMS**

NAME: \_\_\_\_\_

- a) a push or a pull \_\_\_\_\_ Pulley
- b) a wheel and axle with teeth or cogs \_\_\_\_\_ Force
- c) a type of floating bridge \_\_\_\_\_ Fulcrum
- d) when a force pulls on an object \_\_\_\_\_ Arch
- e) first-class lever \_\_\_\_\_ Gear
- f) second-class lever \_\_\_\_\_ Gravity
- g) third-class lever \_\_\_\_\_ Heat
- h) cables are important with this type of bridge \_\_\_\_\_ Newtons
- i) a wheel axle and a rope \_\_\_\_\_ Machine
- j) when an object is squeezed \_\_\_\_\_ Crowbar
- k) strong shape used in Roman architecture \_\_\_\_\_ Suspension
- l) a beam used for support \_\_\_\_\_ Concrete
- m) a downward force created by mass \_\_\_\_\_ Wheelbarrow
- n) force caused by air \_\_\_\_\_ Tension
- o) force is measured in these units \_\_\_\_\_ Compression
- p) friction forces often cause this \_\_\_\_\_ Truss
- q) sand, gravel, water and cement \_\_\_\_\_ Tweezers
- r) makes work easier \_\_\_\_\_ Block And Tackle
- s) a fixed and moveable pulley used together \_\_\_\_\_ Air Pressure
- t) pivot point in a lever \_\_\_\_\_ Pontoon



**PICTOGRAMS - FORCES AND STRUCTURES**

NAME: \_\_\_\_\_

Instructions: Solve these difficult brain teasers using the clues provided:

1. \_\_\_\_\_

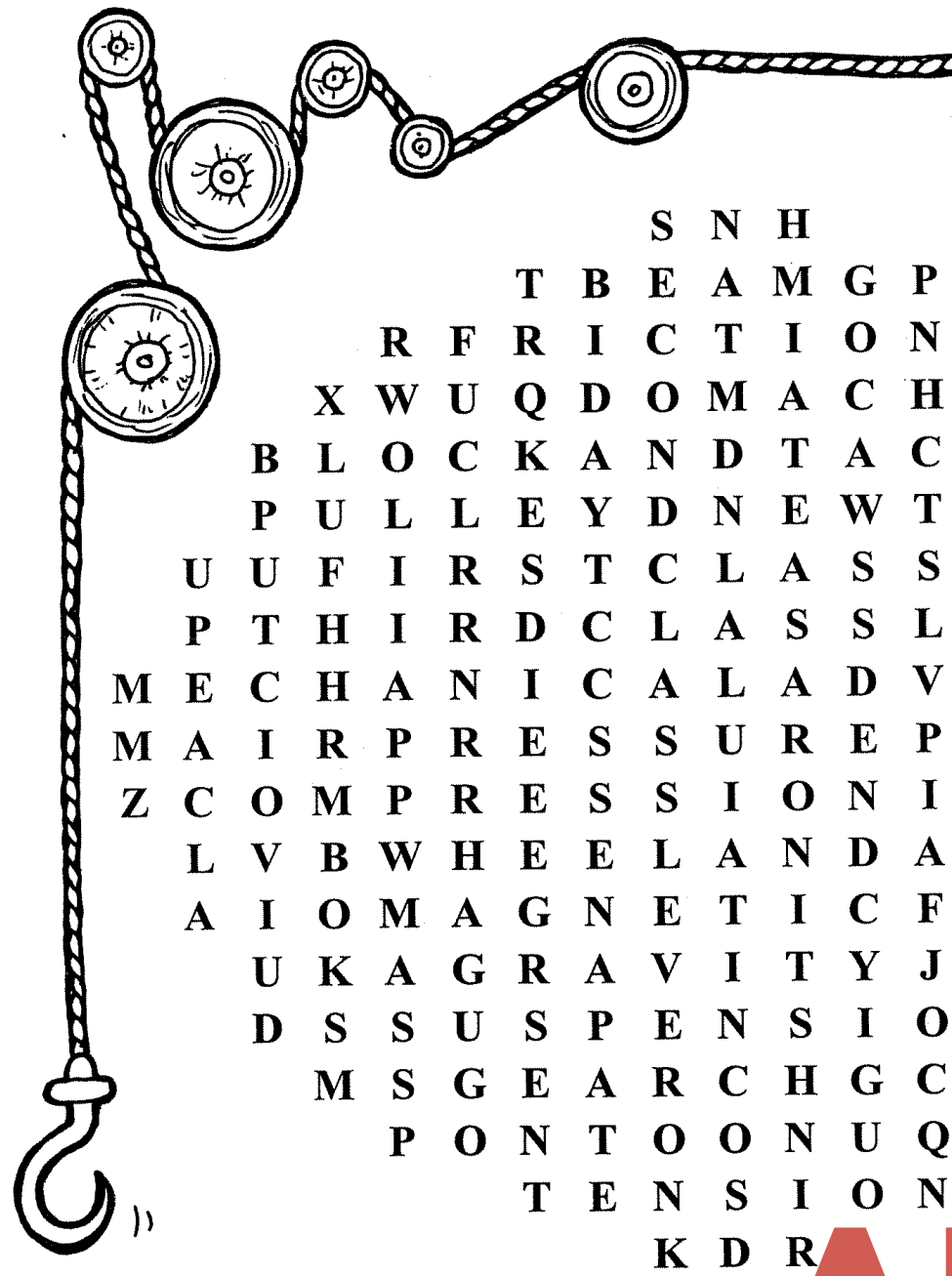
2. \_\_\_\_\_

3. \_\_\_\_\_

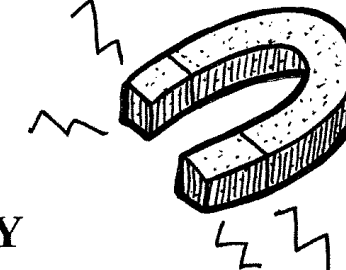
4. \_\_\_\_\_ (A Mediterranean Island)

5. \_\_\_\_\_


# FORCES ON STRUCTURES AND MECHANISMS



NAME: \_\_\_\_\_



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



Find These Words:

- AIR PRESSURE
- ARCH
- BEAM
- BLOCK AND TACKLE
- COMPRESSION
- FIRST CLASS LEVER
- FRICTION
- FULCRUM

- GEAR
- GRAVITY
- MACHINE
- MAGNETIC FORCE
- MASS
- MECHANICAL ADVANTAGE
- NEWTONS
- PONTOON

- PULLEY
- SECOND CLASS LEVER
- SUSPENSION
- TENSION
- THIRD CLASS LEVER
- TRUSS
- WHEEL AND AXEL

# ANSWER KEY

## UNIT #1 - WHAT IS FORCE? TYPES OF FORCES

### Unit Objectives and Activities

Students understand what a force is (a push or a pull) and learn that force is measured in "Newtons".

Four basic types of force are listed (gravity force, air pressure - force of air, force of friction and magnetic force).

Students complete notes on the topic and an introductory wordsearch.

### Suggested Teaching Strategies

Introduce the unit by letting students watch the final ten minutes of the 3<sup>rd</sup> *Star Wars* movie, "Return Of The Jedi". The scene features a battle between Luke Skywalker and the Emperor in which they fight each other using "The Force".

Before showing the movie clip, challenge students to try and guess the new topic in science.

Once students view the clip and have an idea of the new topic in science, explain the hands-on nature of many of the assignments. Reinforce that students will have to be "mature" if they want to do some of the rather involved activities, such as building bridges.

### Note \*\*\*

Admittedly, the way "The Force" is depicted in the movie is a bit of a "stretch" and not well related to forces in the real world. However, the clip is mainly designed to spur student interest in the upcoming unit.

Work with the notes about the forces. Notes can be written on the board or shown as overheads, at the discretion of the teacher.

An easy, introductory wordsearch activity designed to familiarize students with some of the vocabulary words in the unit, "Forces On Structures And Mechanisms", is then completed.

### Answer Key