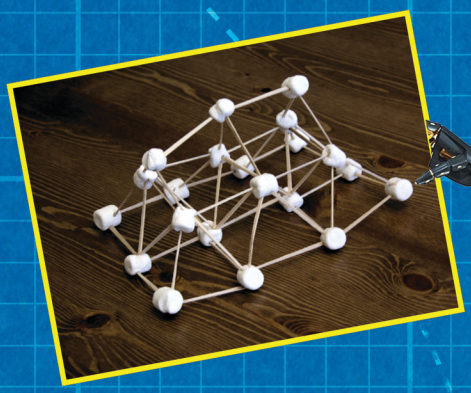
MARSHMALLOW TOWERS



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FOR THE INSTRUCTOR

DESCRIPTION

IN THE MARSHMALLOW TOWERS ACTIVITY, STUDENTS DESIGN AND BUILD A TALL, WEIGHT-BEARING TOWER USING ONLY MARSHMALLOWS AND TOOTHPICKS. THIS PROJECT INCORPORATES ENGINEERING DESIGN, TEAM PROBLEM SOLVING, STRUCTURAL ANALYSIS, BASIC EFFICIENCY COMPUTATIONS, AND GROSS AND FINE MOTOR ACTIVITIES. EACH STRUCTURE IS EVALUATED FOR STABILITY UNDER LOAD AND RATED FOR EFFICIENCY BY COMPARING THE WEIGHT HELD WITH THE WEIGHT OF THE STRUCTURE ITSELF. EFFICIENCY IS FURTHER ASCERTAINED BY CONTRASTING WEIGHT EFFICIENCIES WITH HEIGHT.

GRADE LEVEL

5–8

TIME REQUIREMENT

APPROXIMATELY 90 MIN.

MATERIALS:

- 123 WOODEN TOOTHPICKS
- 111 PENNIES
- 1 BAG OF MINI MARSHMALLOWS
- SMALL MARGARINE TUB LID OR STURDY PAPER COCKTAIL PLATE
- 18" SQUARE CARDBOARD BASE (MARKED WITH A TARE WEIGHT)
- GRAPH PAPER
- UNLINED SKETCH PAPER
- PENCILS
- 12" RULE
- DATA COLLECTION WORKSHEETS (ONE PER STUDENT)

GENERAL MATERIALS

- DIGITAL SCALE
- CALCULATOR
- TIMER
- METER STICK (FOR REALLY TALL TOWERS)
- EXTRA PENNIES (FOR REALLY STRONG TOWERS)
- CALCULATION WORKSHEETS
- NAIL CLIPPERS (FOR TRIMMING TOOTHPICK ENDS IF DESIRED)

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PROCEDURES

1. DIVIDE YOUR CLASS OR GROUP INTO TEAMS OF 3 OR 4 STUDENTS. GIVE EACH TEAM 7-10 MINUTES TO DESIGN, ON PAPER, A WEIGHT-BEARING STRUCTURE ACCORDING TO THESE SPECIFIED DESIGN PARAMETERS:

- DESIGN THE TALLEST STRUCTURE YOU CAN TO SUPPORT THE WEIGHT OF UP TO 111 PENNIES
- FOR BUILDING MATERIALS, USE UP TO 123 TOOTHPICKS CONNECTED AT THEIR JUNCTIONS BY MARSHMALLOWS
- THE PINNACLE OF THE TOWER MUST ACCOMMODATE YOUR MARGARINE LID (OR PAPER COCKTAIL PLATE) AND A STACK OF PENNIES
- THE BASE OF THE TOWER IS NOT TO EXCEED THE BOUNDARIES OF YOUR CARDBOARD BASE
- NO OTHER CONSTRUCTION MATERIALS MAY BE UTILIZED
- YOUR TOWER MUST BE FREESTANDING

2. ONCE DESIGNS ARE COMPLETED ON PAPER, GIVE STUDENT TEAMS AN ADDITIONAL 13-15 MINUTES TO CONSTRUCT THEIR TOWERS.

3. UPON COMPLETION, EACH TEAM MEASURES AND RECORDS THE HEIGHT OF ITS TOWER BEFORE STUDENTS BEGIN TO APPLY LOAD. EACH STUDENT RECORDS HIS OR HER DATA INDIVIDUALLY. A SAMPLE DATA COLLECTION WORKSHEET IS PROVIDED AT THE END OF THIS ACTIVITY.

PROCEDURES CONTINUED...

4. TEAMS NOW BEGIN APPLYING LOAD BY PLACING THEIR MARGARINE LIDS OR COCKTAIL PLATES ON TOP OF THEIR TOWERS, AND THEN ADDING ONE PENNY AT A TIME WITH A MINIMUM OF ONE SECOND BETWEEN PLACEMENTS. SUGGEST THAT STUDENTS ADD PENNIES CAREFULLY TO KEEP THE TOWER BALANCED. EACH TEAM CONTINUES ADDING PENNIES UNTIL THE STRUCTURE FAILS. (MORE PENNIES WILL BE AVAILABLE IF A TEAM'S TOWER IS ABLE TO HOLD ALL 111 PENNIES. FAILURE IS OUR GOAL!)

5. AFTER FAILURE, COUNT THE PENNIES (MINUS THE ONE-TOO-MANY PENNY), WEIGH THE PENNIES AND THE LID OR PLATE, AND MEASURE THE TOWER'S HEIGHT AFTER FAILURE. STUDENTS RECORD DATA INDEPENDENTLY.

6. TEAM MEMBERS NOW WORK INDEPENDENTLY TO PERFORM TWO EFFICIENCY CALCULATIONS USING THE FORMULAS PROVIDED BELOW. TEAM MEMBERS REASSEMBLE TO COMPARE RESULTS FOR CONFORMATION AND CORRECTIONS.

7. ALL TEAMS REPORT THEIR RESULTS TO THE LARGER GROUP TO DETERMINE WHICH STRUCTURE ACHIEVED THE HIGHEST BASE EFFICIENCY AND HIGHEST HEIGHT/WEIGHT EFFICIENCY.

8. THE CLASS OR GROUP CAN THEN ENGAGE IN A JOINT DISCUSSION TO ANALYZE THE RESULTS BASED ON THE EXPLORATORY QUESTIONS INCLUDED WITH THE DATA COLLECTION WORKSHEET.

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FORMULAS

STRUCTURAL EFFICIENCY IS DETERMINED BY DIVIDING THE WEIGHT THE STRUCTURE SUPPORTED BEFORE FAILURE BY THE WEIGHT OF THE STRUCTURE ITSELF. THE HIGHER THE NUMBER, THE GREATER THE EFFICIENCY. (WEIGHT INCREMENTS CANCEL OUT IN CALCULATION.)

EFFICIENCY = WEIGHT SUPPORTED/STRUCTURE WEIGHT

EFFICIENCY RELATIVE TO HEIGHT IS DETERMINED BY MULTIPLYING THE BASE EFFICIENCY PREVIOUSLY CALCULATED BY THE HEIGHT OF THE STRUCTURE BEFORE FAILURE. AGAIN, THE HIGHER NUMBER INDICATES GREATER EFFICIENCY.

HEIGHT/WEIGHT EFFICIENCY = HEIGHT X WEIGHT SUPPORTED/STRUCTURE WEIGHT

PROCEDURAL MODIFICATIONS:

AS AN ENGINEERING DESIGN ACTIVITY, MARSHMALLOW TOWERS CAN SERVE AS AN INTRODUCTION TO BASIC STRUCTURAL ENGINEERING PRINCIPALS. STUDENTS CAN BE GUIDED TO RECOGNIZE COMMON DESIGN ELEMENTS IN STRUCTURES THAT HAVE EXPOSED CONSTRUCTION SUCH AS TOWERS AND BRIDGES. THIS EXAMINATION WILL REVEAL A SIGNIFICANT DESIGN ELEMENT, THE TRIANGLE.

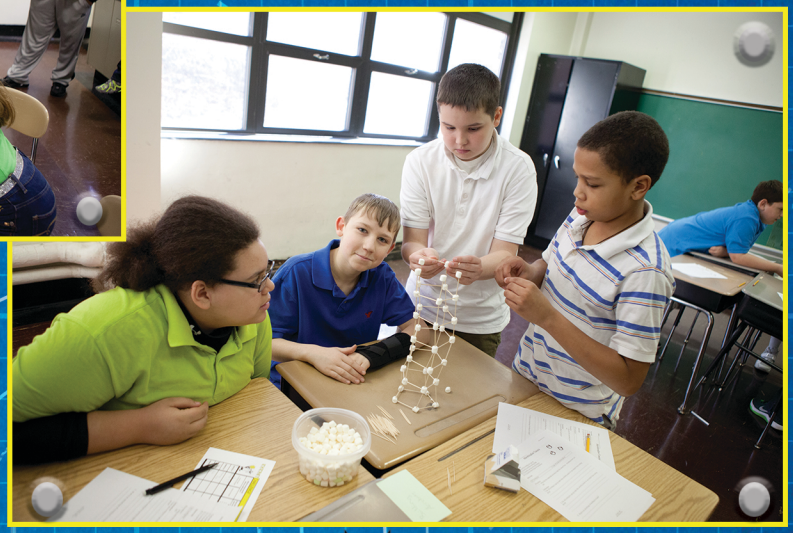
MOST OF THE TOWERS STUDENTS FIRST BUILD WILL CONSIST OF A COLLECTION OF INTERCONNECTED CUBES; THEY RARELY EMPLOY A STRUCTURAL MEMBER BISECTING THE FACE OF THEIR CUBES INTO TRIANGLES. USE A SIMPLE DEMONSTRATION TO SHOW HOW THE ADDITION OF TRIANGLES WITHIN THE DESIGN PREVENTS THE EASY COLLAPSE OF A SQUARE OR RECTANGULAR FACE. STUDENTS CAN THEN REDESIGN, REBUILD, AND RETEST THEIR STRUCTURES.

CONTINUED...

UNIT OF STUDY DEVELOPMENT

AN EXAMINATION OF BRIDGES WILL ALSO EXPOSE STUDENTS TO THE CONCEPT OF SUSPENSION AS ANOTHER MEANS TO SUPPORT A SPANNING STRUCTURE. THIS CAN LEAD TO THE DEVELOPMENT OF A UNIT OF STUDY THAT EXAMINES TENSION AND COMPRESSION MEMBERS AND THE USE OF CONSTRUCTION MATERIALS AND SYSTEMS DESIGNED FOR EFFICIENCY AND ELEGANCE, SUCH AS CABLE-STAYED STRUCTURES.

INCORPORATION OF ADDITIONAL MATHEMATICAL ANALYSIS SHOULD ALSO BE CONSIDERED. STUDENTS CAN EMPLOY FORMULAS TO CALCULATE AREA, VOLUME, AND THE LOAD EXERTED UPON THEIR TOWERS. QUANTIFIED SOLUTIONS ALSO LEND THEMSELVES TO CONVERSION EXERCISES AND DISCUSSIONS OF UNITS OF MEASUREMENT SUCH AS POUNDS PER SQUARE INCH AND GRAMS PER CENTIMETER SQUARED.



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STUDENT DATA COLLECTION WORKSHEET

HEIGHT OF TOWER BEFORE TESTING	
HEIGHT OF TOWER AFTER FAILURE	
NUMBER OF PENNIES SUPPORTED	
WEIGHT SUPPORTED	
WEIGHT OF STRUCTURE	

BASE EFFICIENCY CALCULATION
(USE ADDITIONAL PAPER AS NEEDED)

HEIGHT/WEIGHT EFFICIENCY CALCULATION
(USE ADDITIONAL PAPER AS NEEDED)

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MARSHMALLOW TOWERS

EXPLORATORY QUESTIONS (USE ADDITIONAL PAPER AS NEEDED)

WHAT DID YOU KNOW ABOUT BUILDING A STABLE STRUCTURE BEFORE DOING THIS ACTIVITY? WHERE DID YOU LEARN IT?

HOW DID YOU BUILD YOUR STRUCTURE? WHY DID YOUR TEAM MAKE THESE DESIGN CHOICES?

AT WHAT POINT DID YOUR STRUCTURE FAIL? WHY DO YOU THINK YOUR STRUCTURE FAILED WHEN IT DID?

IF YOU WERE TO BUILD A SECOND STRUCTURE WITH THE SAME DESIGN SPECIFICATIONS, WHAT WOULD YOU DO THE SAME? WHAT WOULD YOU DO DIFFERENTLY?

IF YOU COULD CHANGE THE DESIGN SPECIFICATIONS, HOW WOULD YOU DO THAT?

WHERE COULD YOU LEARN MORE ABOUT BUILDING STRUCTURES SO YOU COULD MAKE A MORE STABLE TOWER?

ARE THERE OTHER MATHEMATICAL CALCULATIONS YOU COULD PERFORM RELATED TO THE TOWER AND IT'S TESTING?