Workbook Preview

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Grade 7 Science Unit

Form, Function, and Design of Structures

D1 - Relating Science and Technology to Our Changing World
D2 - Exploring and Understanding Concepts

	Curriculum Expectations	Pages
D1.1	evaluate environmental, social, and economic factors that should be considered when designing and building structures to meet specific needs for individuals and communities	74–76, 79–94, 100–110, 112–116
D1.2	evaluate the impact of the ergonomic design of various tools, objects, and work spaces on a user's health, safety, and ability to work efficiently, and use this information to describe changes that could be made in their own spaces and activities	122–128
D2.1	c s	20
D2.2	d t	26–31
D2.3	identify the magnitude, direction, point of application, and plane of application of the forces applied to a structure	41–62, 65–70, 73
D2.4	describe the role of symmetry in structures, and identify instances of symmetry in various structures	74–78
D2.5	describe factors that can cause a structure to fail	29–31, 79–94
D2.6	identify the factors that determine the suitability of materials for use in manufacturing a product or constructing a structure	95–110
D2.7	describe methods engineers and other professionals use to assess, improve, and maintain the safety of structures	111–116

Preview of 100 pages from this product that contains 207 pages total.

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Grade 7 Science Unit

Strand A - STEM Investigation and Communication Skills

	Curriculum Expectations	Pages
A1.1	use a scientific research process and associated skills to conduct investigations	119–121, 129–131
A1.2	use a scientific experimentation process and associated skills to conduct investigations	25, 38–40, 63–64
A1.3	use an engineering design process and associated skills to design, build, and test devices, models, structures, and/or systems	21–22, 71–72, 117–121, 129–131
A1.4	follow established health and safety procedures during science and technology investigations, including wearing appropriate protective equipment and clothing and safely using tools, instruments, and materials	21–22, 25, 38–40, 63–64, 71–72, 117–121, 129–131
A1.5	communicate their findings, using science and technology vocabulary and formats that are appropriate for specific audiences and purposes	21–22, 25, 38–40, 63–64, 71–72, 117–121, 129–131
A2.1	write and execute code in investigations and when modelling concepts, with a focus on planning and designing programs	32–33, 132–133, 136
A2.2	identify and describe impacts of coding and of emerging technologies, such as artificial intelligence systems, on everyday life, including skilled trades	32–33, 132–135, 137–138
A3.1	describe practical applications of science and technology concepts in various occupations, including skilled trades, and how these applications address real-world problems	32–33, 132–135, 137–138
A3.2	investigate how science and technology can be used with other subject areas to address real-world problems	32–33, 132–135, 137–138
A3.3	analyse contributions to science and technology from various communities	32–33, 132–135

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NAME: _____

FORM, FUNCTION, AND DESIGN OF STRUCTURES



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Curriculum Connection
D2.1

Structures – Form and Function

What is a Structure?

A **structure** is something made of many parts that is put together to serve a purpose. Our bodies are structures, as they have bones that are put together to serve a purpose – giving our muscles support so we can move.



Form and Function of Structures

Structures are all around us. Every structure has a function, meaning it was built to do something. A bridge is a structure that is commonly made of materials like wood, metal, and/or plastic. A chair's function is to support a person's load so they can rest. Therefore, the **function** of a structure is the structure's purpose – what it needs to do.

The **form** of a structure is how the materials or parts are organized in order to serve the structures function. The form is the shape of the structure. The form of a structure is very important because it affects the stability of the structure.

Form Follows Function

The phrase, "form follows function" was coined by architect Louis H. Sullivan in 1896. **Form follows function** means that when we make a structure, we need to understand the function of the structure before we build it. In other words, we need to know what forces will act on the structure before we can decide what materials we will use and how we will arrange the materials.



Imagine someone asking you to build a bridge. Without anymore information, you would have no idea what type of bridge to make. You might ask:

1) How long does the bridge need to be?
2) What loads will use the bridge – people, animals (pets), cars, transports?
3) How long will the bridge need to last?
4) How much money will I be paid to build the bridge?

Understanding the answers to these questions will help you understand the function of the structure and will allow you to make a bridge that works for the purpose.

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Curriculum Connection
D2.1

Questions

Use information from the text to support your answer.

1) What does form follows function mean? Why is it important?

2) Define t[illegible]s below.

S[illegible]	
Form	
Function	

PREVIEW

Visualizing

What wer[illegible]pict[illegible]r head while you were reading?

True or False

Circle whether the statement is true or false.

1) Structures are materials found in the environment.	True	False
2) Structures are the arrangement of materials or parts to form something.	True	False
3) It is good to build structures without knowing how they will be used.	True	False
4) We need to understand the function of a structure before we build it.	True	False
5) Understanding the loads that will act on a structure is important.	True	False

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Curriculum Connection
D2.1

Exit Cards

Cut Out Cut out the exit cards below and have students complete them at the end of class.

Name: _____ Mark

Check only the true statements.

Statement	✓
Every structure is designed to serve a purpose.	
A structure's form describes its purpose.	
A structure's function affects how it should be designed.	
Materials should be chosen to suit a structure's function.	
The shape of a structure can affect its stability.	
All structures are made from the same materials.	
A bridge's expected load can affect its design.	
Form and function are unrelated when designing structures.	

Name: _____ Mark

Check only the true statements.

Statement	✓
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Form and function are unrelated when designing structures.	

PREVIEW

Name: _____ 15

Curriculum Connection
D2.1

Types of Structures – Shell, Solid, Frame

Types of Structures



When we understand the function of a structure, we can begin to decide which form we will use. There are three main forms: shell, solid, and frame structures.

Shell Stru

A **shell s** as strong layer on the outside that holds itself up. Shell structures are u curved ively thin, allowing for an interior space. Common examples of shell structu ut ls, mugs, dome arenas, igloos, basketballs, and tin cans. Shell struc ve a l th compared to their weight, which makes them useful in covering larg ar ry simple in design compared er t structures.



Solid Structures

A **solid structure** has no space inside and is usu made of one solid material. A hydro dam is a solid structure built of concrete that is used to block the movem wat ples of solid structures are rocks, bricks, and cement patio stones. Each s have no space inside and are made of one material. Solid structures are heavy and strong. Well made solid structures can last a long time.

Frame Structures

A **frame structure** is a structure that has a combination of horizontal beams and vertical columns that form a skeleton that can be covered or open. A frame structure is like a shell as it has space inside, but the frame structure will have beams and columns that make the shell stronger. While an igloo shelter is a shell, a house is a frame shelter because it usually has walls (columns) and floors (beams). Some examples of frame structures are buildings, spider webs, trees, bicycles, and bridges.

PREVIEW

Name: _____ 16

Curriculum Connection
D2.1

Questions
Use information from the text to support your answer.

1) What is the difference between a frame and a shell structure?

2) Write down three examples of each type of structure you can see right now.	
Frame	
Solid	

PREVIEW

Type of Structure?
Is the structure a shell, frame, or solid structure?

1) House	Shell		Solid
2) Eggshell	Shell		Solid
3) Car	Shell	Frame	Solid
4) Telephone pole	Shell	Frame	
5) Bottle	Shell	Frame	
6) Pyramid	Shell	Frame	Solid
7) Beehive	Shell	Frame	Solid
8) Leaf	Shell	Frame	Solid

Questioning
Write 2 questions you have about the reading.

1)	
2)	

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Curriculum Connection
D2.1

Shell, Frame, and Solid Structure

Directions Draw three different chairs – one shell, one frame, and one solid.

Shell Chair	
Diagram	**Explanation**
	_____ _____ _____ _____ _____

Fr	
Diagram	**Explanation**
	_____ _____ _____ _____ _____

Solid Chair	
Diagram	**Explanation**
	_____ _____ _____ _____ _____

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Curriculum Connection
D2.1

Research Assignment – Type of Structure

Learn more about one type of structure – shell, frame, or solid.
Answer the questions below by researching the structure type online.



Research Answer the questions below.

1) Which t[illegible]f structure did you choose – shell, frame, or solid?

2) W[illegible]of this type of structure?

3) What are the disadvantages of this type of stru[illegible]?

4) What are some common examples of this type of structure?

Human Made	Natural (naturally made in our environment)

PREVIEW

Curriculum Connection
D2.1

Research Answer the questions below.

5) Find a famous or popular structure. What is the name of the structure? Find some information about the structure – cost, when it was built, where it is.

6) Dra[illegible] write what materials were used to build it.

7) What is the function of the structure - why w[illegible]ilt or [illegible]it do?

8) Why did the engineer/architect use this type of structure? What are the advantages for this structure for the function of it?

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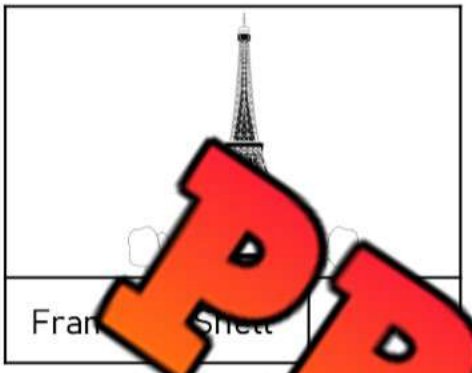
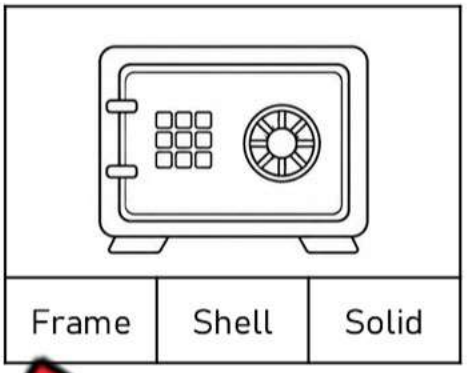
Curriculum Connection
D2.1

Types of Structures

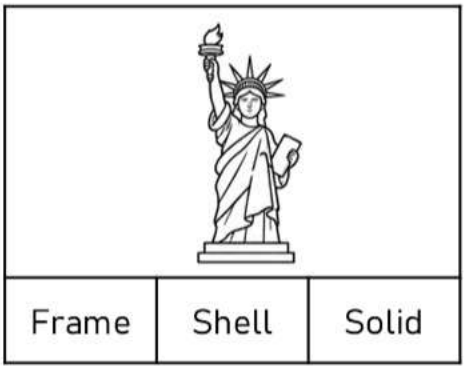
Structure Type	Which type of structures are shown in the pictures below?



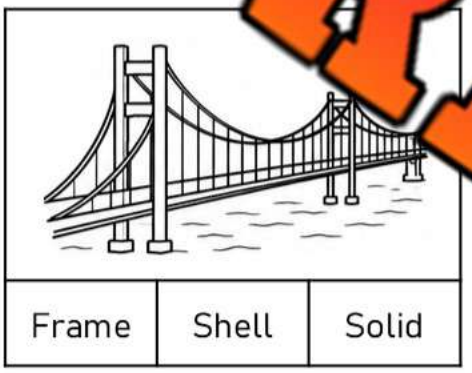
Frame	Shell	Solid



Frame	Shell	Solid



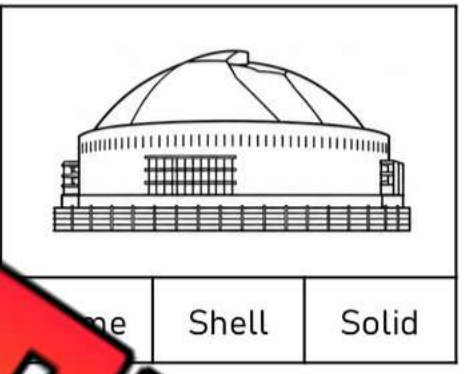
Frame	Shell	Solid



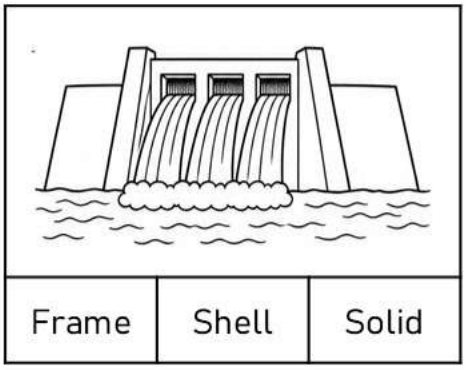
Frame	Shell	Solid



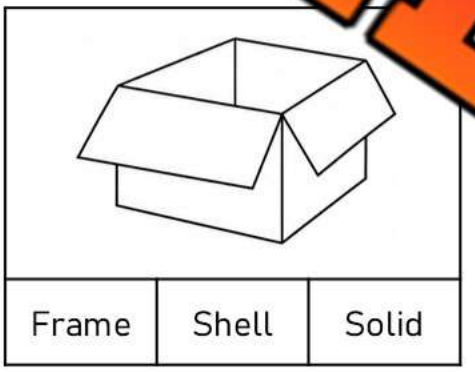
Frame	Shell	Solid



Frame	Shell	Solid



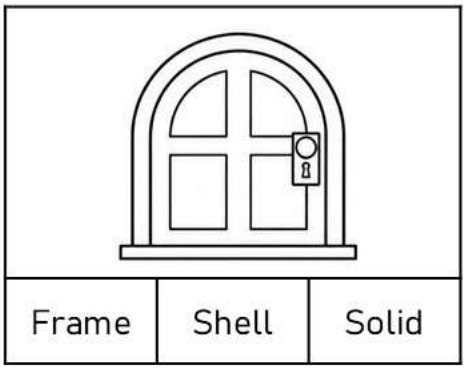
Frame	Shell	Solid



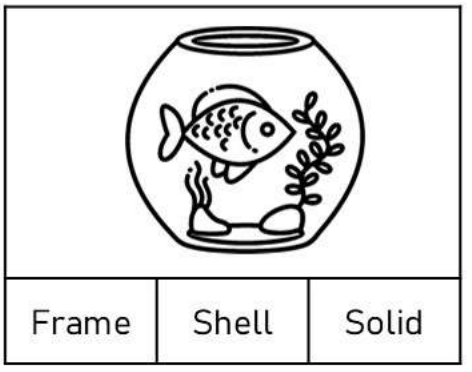
Frame	Shell	Solid



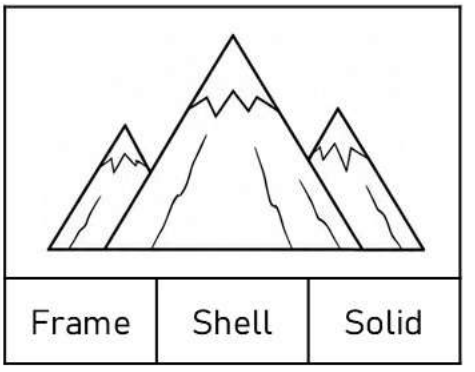
Frame	Shell	Solid



Frame	Shell	Solid



Frame	Shell	Solid



Frame	Shell	Solid

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Curriculum Connection
A1.3, A1.4, A1.5

Experiment – Frame, Shell, and Solid Structures

Background — What is the activity?

Can you design three types of chairs – one shell, one frame, and one solid? Using clay and toothpicks, your challenge is to make three different types of chairs.







PREVIEW

Materials — What you need?

- ✓ Clay or playdough
- ✓ Toothpicks
- ✓ Scissors



Method — How will you complete the experiment?

1) Hand out materials – 16 toothpicks and a handful of clay or playdough.
2) On the next page, build your chair structures.
3) Cut the pointed ends on the toothpicks to make them sturdier.
4) Draw the chairs you made when you are finished.



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Curriculum Connection
A1.3, A1.4, A1.5

Design Create your chairs below.

Solid	Frame	Shell

PREVIEW

Results w[illegible]ne qu[illegible]below.

1) Which type of chair str[illegible]is [illegible]he str[illegible]turdiest? Explain why.

2) Which type of chair is the most visually appealing? Wh[illegible]e lo[illegible]he c[illegible]air matter?

3) Which type of chair is the least comfortable and least stable?

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Curriculum Connection
D2.2

Centre of Gravity

Gravity

What goes up must come down. That is true because of gravity, the force that pulls everything towards the Earth's centre. Sometimes gravity can make things turn or topple over. Tall buildings will topple over if they are not stable because gravity is pulling the building do towards the Earth's centre.

Centre of

The t di

more di ult it is

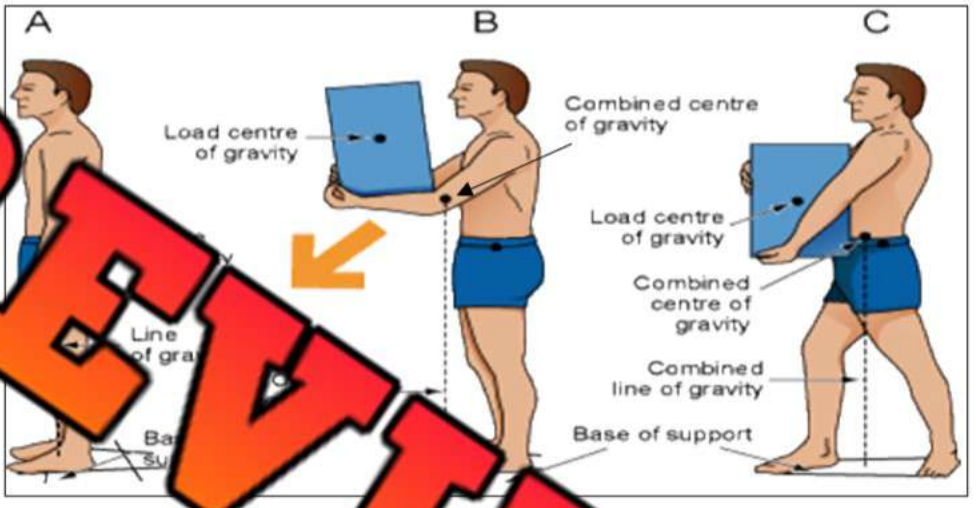
engineers to m e

and not fall over. Bu

understand an important

scientific principle called

centre of gravity. The



PREVIEW

Centre of gravity (CG) is an imaginary point on a st re wh weight of the structure is evenly dispersed around it. This mea t the ght on all sides – above, below, in front, behind, and on both sides.

A ball has a clear centre of gravity with it being right i cen s, the centre of gravity is a bit more complicated. It is slightly above o we have more weight on the top half of our body than the bottom half.

Tall structures will topple over easier because their centre of gravity is higher. If you build a tower of blocks with a stack of single blocks on top of each other, it will eventually fall. The centre of gravity is in the centre of the tower. As you build the tower higher, the CG becomes higher as well, making it more unstable. But if you make the base wider, the centre of gravity will be lower because there is more weight on the bottom. The tower will be more stable if the bottom half of the tower has more blocks.

When engineers and architects design structures, they must understand the CG of the structure. Keeping the centre of gravity as low as possible will increase its stability.

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Curriculum Connection
D2.2

Questions

Use information from the text to support your answer.

1) What does centre of gravity mean? Why is it important?

2) If you w[illegible] designing a structure, how could you use your understanding of CG to ensure it i[illegible]?

PREVIEW

Diagram

Draw a diag[illegible] a t[illegible]bel where its centre of gravity is.

Des[illegible] wh[illegible] the CG is and how you k[illegible] low.

True or False

Circle whether the statement is true or false.

1) A structure's CG is always in the middle of the structure.	True	False
2) A structure's CG is where there is equal weight surrounding it.	True	False
3) The lower the CG, the more stable a structure is.	True	False
4) In football, you have more stability/balance when you're standing straight up.	True	False
5) A tower with a wider base has a lower CG.	True	False

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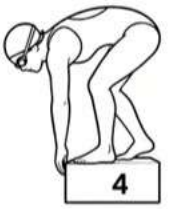
Curriculum Connection
A1.2, A1.4, A1.5

Experiments – Centre of Gravity

We can demonstrate the importance of the concept of centre of gravity by performing the activities below. Follow the instructions and answer the questions.



Activities Follow the instructions and answer the questions.

1) Stand w back and feet against a wall. Have someone place a pencil at your feet. Try to pi ding forward without moving your feet.

What nt forward? Why did that happen?

2) Stand against a wall sideways with yo rm and ouch the wall, with nothing to hold on to. Try to lift your other leg straight out e wa

Were you able to do it? Why not? Why is this impo e?

3) Get on all fours (knees and hands on the ground). Now try to put your hands behind your back (do not shoot hips back, try to keep them above your knees).

Did you fall down? Explain why or why not. Also, ask around the class as some people (females) might be able to do this easier as males tend to have a higher CG than females.

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Name: _____ 26

Curriculum Connection
D2.2

Centre of Gravity – Which is More Stable?

Evaluate Circle the structure that is more stable. Explain why below.

1)





2)





3)





4)





PREVIEW

Name: _____ 27

Curriculum Connection
D2.2

Fact or Fiction? Centre of Gravity & Stability

Objective

What are we learning about?

Students will explore how centre of gravity, height, base width, and balance affect the stability of structures by deciding whether different statements are fact or fiction.

Materials

What will you need for the activity?

- Fact or Fiction statements
- A 'Fact' sign and a 'Fiction' sign to distinguish the two sides of the room
- Designated areas in the classroom for the 'Fact' and 'Fiction' signs, allowing students to move to either side



Instructions

How will you complete the activity?

1) Your teacher will read statements. Pay close attention as each is shared.
2) Consider carefully whether you think the statement is true or false.
3) If you decide the statement is true, walk to the 'Fact' side of the room.
4) If your guess is that it's not true, move to the 'Fiction' side of the room.
5) Stay on your chosen side and listen attentively for the correct answer to be revealed.
6) When the right answer is announced, return to your seat, ready for the next round.
7) Have fun getting up and moving!

PREVIEW

Name: _____ 28

Curriculum Connection
D2.2

Fact or Fiction | Read the statements to the class.

#	Statement	
1	A wider base can make a structure more stable.	Fact
2	A higher centre of gravity always increases stability.	Fiction
3	Centre of gravity affects how easily something tips.	Fact
4	Tall st can never be stable.	Fiction
5	ntre of gravity can increase stability.	Fact
6	A na ow bas es object harder to tip.	Fiction
7	An object can centr utside its material.	Fact
8	Adding weight near th educe	Fact
9	Base width has no effect on st ity.	Fiction
10	A structure must be symmetrical to re standi	Fiction
11	Spreading weight evenly can improve a structu lanc	Fact
12	A shorter structure is always less stable than a taller o	Fiction
13	Leaning can move a structure's centre of gravity.	act
14	A heavy object is automatically more stable than a light one.	Fiction
15	Stability depends partly on how weight is distributed.	Fact
16	The Leaning Tower of Pisa has no centre of gravity.	Fiction
17	A structure can fall if its centre of gravity shifts too far.	Fact
18	Increasing the height always makes a structure more balanced.	Fiction
19	Engineers consider centre of gravity when designing structures.	Fact
20	Two objects of equal height must have equal stability.	Fiction

PREVIEW

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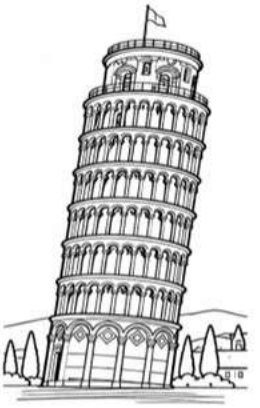
Curriculum Connection
D2.2, D2.5

Leaning Tower of Pisa – Centre of Gravity

History of the Leaning Tower of Pisa



The Leaning Tower of Pisa has been leaning for over 800 years. It was built in 1173, but because of several interruptions, it wasn't completed until the mid-1300s. It was built as a belltower for the church nearby.

Why Does the Tower of Pisa Lean?

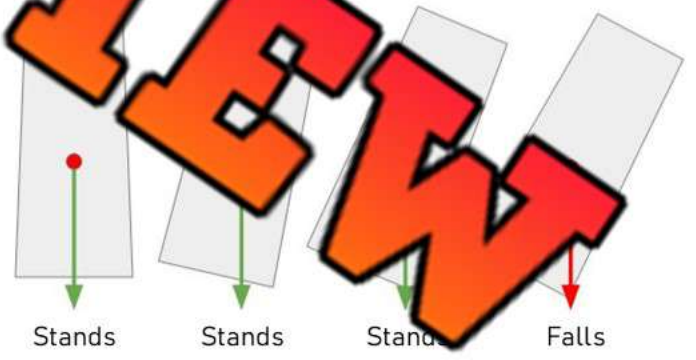
The soft ground shifted the soil, which destabilized the tower's foundation. The soil underneath is made of clay, fine sand, and shells. It is too soft of a foundation for such a heavy structure. The ground was uneven, causing the one side of the building to compress into the soil more than the other side.

For the last 800 years, the tower has been not only leaning, but actually falling at a rate of two millimetres per year. The Leaning Tower of Pisa is more than five metres off perpendicular (straight up).

While making the tower, the architect engineer noticed the lean after they built the 3rd story out of 8 stories total. They made the next stories slightly taller on the short side of the tower in an attempt to counteract the lean. Their plan backfired, as the weight of the extra floors caused the structure to sink further and lean more.

PREVIEW

Leaning Tower of Pisa – Centre of Gravity



Any object will remain standing if when we draw a line from the CG straight down to the ground, the line stays within the structure of the building.

In 1990, the Tower reached an inclination of 5 degrees, which became close to the dangerous limit of the CG falling outside of the outer edge of the building.

A massive engineering project was performed to return the Tower to a 4-degree inclination. They held up the Tower using cables while they dug under the Tower's north side – the opposite side it was leaning. As they dug, the tower automatically began shifting into the hole they dug.

Future of the Tower

The Tower needs constant monitoring, to ensure it doesn't fall. It will likely need more corrections, like the one described above. Also, if a massive storm, earthquake or other natural disaster strikes, it could send the Tower to the ground. Luckily, Tuscany hasn't experienced any major natural disasters in the last 800 years.

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Name: _____ 30

Curriculum Connection
D2.2, D2.5

Questions

Use information from the text to support your answer.

1) Why is the Leaning Tower of Pisa falling?

2) Will th ver fall? Explain how they fixed the lean.

PREVIEW

Questioning

Write 3 question you eaning Tower of Pisa.

1)	
2)	
3)	

True or False

Circle whether the statement is true or false.

1) The Leaning Tower of Pisa has not fallen in 800 years.	True	False
2) The Tower is just leaning, not falling.	True	False
3) The CG on the Tower was close to being outside of its edge in the 1990s.	True	False
4) The lean was not noticed until after the Tower was built.	True	False
5) The soft soil of clay, sand, and shells led to the Tower leaning.	True	False

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Curriculum Connection
D2.2, D2.5

Exit Cards

Cut Out Cut out the exit cards below and have students complete them at the end of class.

Name: _____ Mark

Fill in the blank space.

1) The point where an object's weight is balanced is called its _____.

2) The Tower of Pisa began leaning because the ground beneath its _____ settled unevenly.

3) A structure remains standing when its centre of gravity stays within its _____.

4) If the centre of gravity moves outside the base, the structure may _____.

5) Engineers used cables to help _____ the Leaning Tower of Pisa.

Name: _____ Mark

Fill in the blank space.

1) The point where an object's weight is balanced is called its _____.

2) The Tower of Pisa began leaning because the ground beneath its _____ settled unevenly.

3) A structure remains standing when its centre of gravity stays within its _____.

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PREVIEW

Name: _____ Mark

Fill in the blank space.

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2) The Tower of Pisa began leaning because the ground beneath its _____ settled unevenly.

3) A structure remains standing when its centre of gravity stays within its _____.

4) If the centre of gravity moves outside the base, the structure may _____.

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Mark

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4) If the centre of gravity moves outside the base, the structure may _____.

5) Engineers used cables to help _____ the Leaning Tower of Pisa.

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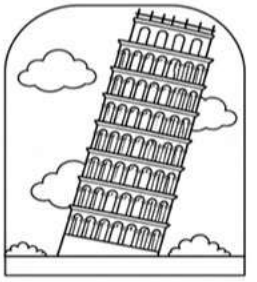
Curriculum Connection
A2.1, A2.2, A3.1, A3.2, A3.3

Coding – Leaning Tower of Pisa

Horizontal Displacement Sensors

Displacement is how far something has moved from its original position. Horizontal means side-to-side. So, **horizontal displacement sensors** measure how far something has moved side-to-side.

The Leaning Tower of Pisa has a horizontal displacement of 4.5 metres. The sensors in the Tower are always monitored because it is a historic building that no one wants to see fall. The Tower actually falls over 1 mm each year.



The [illegible]ews is that computer code has been written to tell engi[illegible]e lean becomes too much for the Tower to stay stable[illegible]k[illegible]f it leans over 5 metres, it could fall. Chec[illegible]a sample[illegible]low.

Did the building move over 5 m?

IF the building [illegible]ed o[illegible]

THEN print, "Dang[illegible]

ELSE

print, "Safe"

PREVIEW

Questions Answer the questions bel[illegible]using in[illegible]om the text.

1) What do horizontal displacement sensors do?

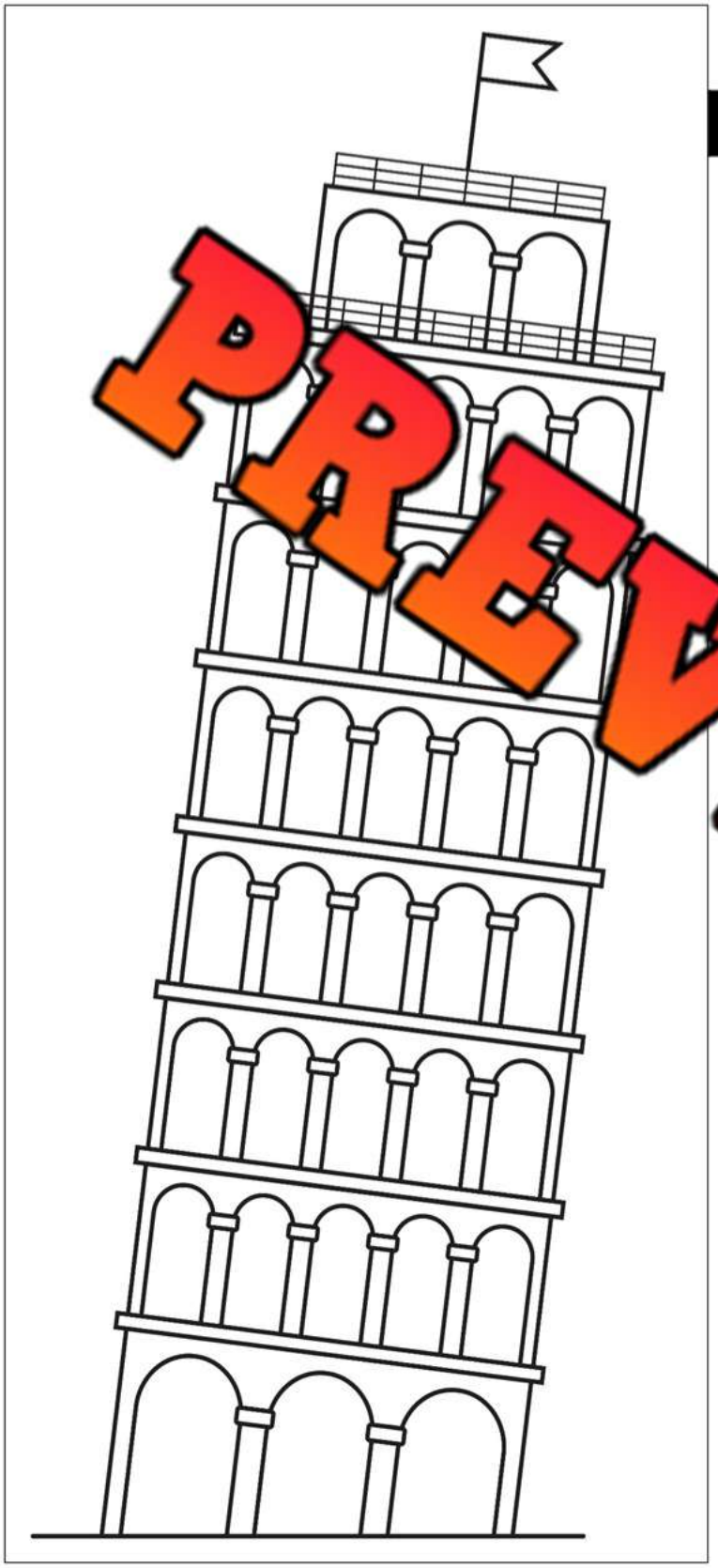
2) How are sensors being used to make sure the Leaning Tower of Pisa d[illegible]all down?

3) Why is coding important in keeping structures strong and stable?

Name: _____ 33

Curriculum Connection
A2.1, A2.2, A3.1, A3.2, A3.3

Colour Colour the Leaning Tower of Pisa Below



Part 2 Follow the instructions below.

1) Where would you put horizontal displacement sensors? Draw 4 of them on the Leaning Tower of Pisa.

2) Write your IF/ELSE statements below.

Did the building move over 5 m?

IF

ELSE

THEN print,

“ _____

_____

_____ ”

THEN print,

“ _____

_____

_____ ”

PREVIEW

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Name: _____ 36

Curriculum Connection
D2.3

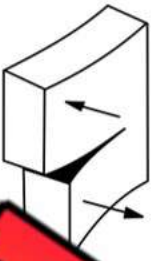
Internal Forces

Internal Forces Resisting Motion in Structures
Structures must be built to withstand the external forces that act on them. Internal forces are forces felt from the inside of structure. The structures are constantly resisting the external forces acting on them. Structures have the following internal forces: compression, tension, shear, and torsion.



Compression
Compression is a pushing internal force. A structure will feel compression inside of it if it is being squeezed or pushed down. When we sit on our chair, we are applying an external force that is our body weight to the chair. If the chair has strong compressive internal strength, it will resist the compression. If not, the chair will collapse.

Tension
Tension is a pulling force. When we pull both ends of a material or structure, we are applying tension to it. Many materials would not break when tension is applied to it because they have tensile strength. A rope or string might break as the internal tensile force would be too strong. It would be very difficult to break a popsicle stick by pulling both ends of it. On the other hand, we could easily break an elastic by applying tension to it and pulling it apart. This means an elastic has less tensile strength than a popsicle stick.



Shear Force
Shear force happens when there are two opposing forces acting on the structure. When you want to open a bag of chips, you might open the bag by applying two opposing forces to the top of the bag. The bag might rip, meaning the shear internal force acting on the bag was too strong for it to resist.

A good example of shear force in action is using scissors. The two blades put force in different directions on the pin that holds the two parts together. The force applied to the pin is called a shear force.

Torsion Force
Torsion is a twisting force that is applied to a structure. The internal force occurs when the structure begins to twist or bend. A common example of torsion is when we twist a wet towel to wring it out.



When engineers design a bridge, they need to understand how much wind the bridge will need to endure. The Tacoma Narrows Bridge sustained damage from strong winds that caused the bridge to twist, meaning its weakness was torsional strength. The internal torsional force was too strong as the bridge couldn't resist the wind's external force, which caused it to twist and collapsed.

PREVIEW

Name: _____ 37

Curriculum Connection
D2.3

Questions

Use information from the text to support your answer.

1) What is an internal force?

2) When h[illegible]ou seen a structure fail due to too strong of an internal force?

PREVIEW

True or False

Circle [illegible] the s[illegible]is true or false.

1) Torsion is a twisting force.	True	False
2) Shear force requires two forces in opposite d[illegible]ns.	True	False
3) Sitting on a chair puts compressive internal fo[illegible]on t[illegible].	True	False
4) Turning a screw into wood is a shear force.	Tru[illegible]	False
5) Turning the tap on is a torsion force.	[illegible]	alse
6) The strings on a guitar are under tension internal forces.	[illegible]	False
7) Tearing a piece of paper is a torsion force.	True	False

Matching

Match the definition to the term.

Answer	Term	Description
	Shear	a) When a structure is exposed to twisting
	Tension	b) When a structure is exposed to pushing or squeezing
	Compression	c) When a structure is exposed to two forces in opposing directions
	Torsion	d) When a structure is being pulled apart

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Curriculum Connection
A1.2, A1.4, A1.5

Investigate – Compression/Tension

Research Question What are we trying to learn more about?

What is the difference between compression and tension? What does compression and tension do to a bridge when acting on it at the same time?

Materials t will you need for this experiment?

- A ge
- A black o er

PREVIEW



Method How will yo te the iment?

1. With a dark marker, draw a serie s across the short side of the sponge. Do this the top and bottom of the sponge.
2. Pass the sponge around and bend it into a U-shape.
3. Observe what happens to the lines on the top and bottom of the sponge. Ask yourself the following questions while investigating.
   - Do some lines get closer together?
   - Do some lines get further apart?
   - Which side of the sponge is under tension?
   - Which side of the sponge is under compression?





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Curriculum Connection
A1.2, A1.4, A1.5

Observations

What happened? Was there compression and/or tension?

1) Did some lines get closer together?	
2) Did some lines get further apart?	
3) Which side of the sponge is under tension?	
4) Which [illegible]nge is under compression?	

PREVIEW

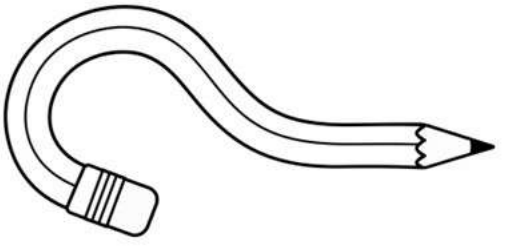
Results

Answer [illegible]

1) How can a bridge be under te[illegible]n ar[illegible]t the same time?

2) Draw a diagram of the sponge when it was in its U-shape and lab[illegible] tension and compression.

3) Put a circle around the parts of the pencil under tension and a rectangle around the parts that are under compression.



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Curriculum Connection
A1.2, A1.4, A1.5

Bridges – Tension or Compression?

Question Is the part of the bridge under tension or compression?



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Curriculum Connection
D2.3

Tacoma Narrows Bridge

Learn more about the engineering failures that led to the Tacoma Narrows Bridge collapsing.



Research Answer the questions below.

1) Where was the bridge located?

2) What was the bridge? When did it collapse?

	Collapsed

3) What internal forces had to be strong in the bridge to resist? Circle the answer.

Compression	Tension		Shear

4) Why did the bridge collapse?

5) What materials was the bridge made of?

PREVIEW

Curriculum Connection
D2.3

Research | Answer the questions below.

6) What external forces were too strong for the bridge's internal forces to overcome?

7) How mu[illegible]id the Tacoma Narrows Bridge cost to build?

8) When did they b[illegible]e sec[illegible]ement bridge? How much did it cost to build?

When	Cost

9) With such a high cost to build, why is [illegible]ortant t[illegible]gineers and architects do a good job planning and designing structur[illegible]s?

10) How was the new bridge built differently than the old bridge?

PREVIEW

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Curriculum Connection
D2.3

Describing External Forces

Describing Forces



We see forces happening in our day-to-day life all the time. You have described these forces to your friends and family. You may have said, "wow, I hit the puck so hard with my slap shot" or, "did you see that huge gust of wind that just knocked that tree down?" In the scientific world, we use key terminology to describe forces.

Terminology – Magnitude

Magnitude is a term used to describe how much force is acting on a structure. All forces have a size or strength. These forces can be measured in terms of the strength which is the magnitude of the force. A weightlifter might say they bench pressed a magnitude of 200lbs of force into the bar.

An earthquake is always described in terms of its magnitude, or strength of its force. The Richter magnitude scale assigns a number to quantify the amount of seismic energy (force) that is released in an earthquake. In 1960, the strongest earthquake ever recorded hit Chile and its effects in Chile, Hawaii, and Japan. It was a magnitude of 9.6 on the Richter scale.



Terminology – Direction

Forces act in a particular direction and have size depending on how strong the push or pull is. The **direction** describes where the force is coming from. If a force is blowing in your face, it is difficult to walk, but if it is blowing at your back, it allows you to walk faster.

It is important to understand the direction of a force, so we have a net force. The **net force** tells us how much force is acting on a structure. In the case of tug of war, if two groups apply the same pulling force on the rope, the rope will not move. This means the net force acting on the rope is a net zero force.

Terminology – Point/Plane of Application

Point of application describes where the force strikes on the structure. **Point of application** is the side of the structure affected by the force. Where a force is applied to a structure is important in understanding how the structure will handle the force.



For example, If a strong force hits the top of a skyscraper, it might have a stronger impact than if it hit the bottom or base of the structure. Some structures are designed to have the user apply a force in a certain area, like the handle on a shopping cart.

PREVIEW

Name: _____ 46

Curriculum Connection
D2.3

Questions

Use information from the text to support your answer.

1) How could you describe the force of hitting a golf ball?

_____

_____

_____

2) Why do[illegible]he point of application of the force matter? Why might the same magnitude and direct[illegible]rce affect a structure differently depending on the point of application?

_____

_____

_____

_____

Making Connections

What is [illegible] the [illegible]ces you have seen? Describe it using magn[illegible]ude, [illegible] and [illegible] of application.

_____

_____

_____

_____

_____

True or False

Circle whether the statement is true or false.

1) The direction of forces acting on a structure could lead to a net zero force.	True	False
2) The magnitude of a force explains where the force is applied.	True	False
3) The point of application of a force is where the force is applied.	True	False
4) Forces don't happen very often, so we should look carefully for them.	True	False
5) A handle provides a good point of application for our muscular force.	True	False

PREVIEW

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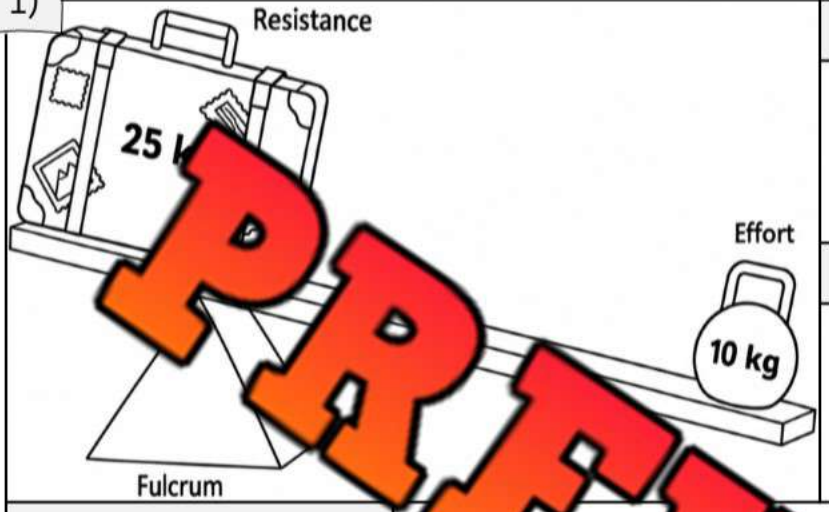
Curriculum Connection
D2.3

Describing Forces

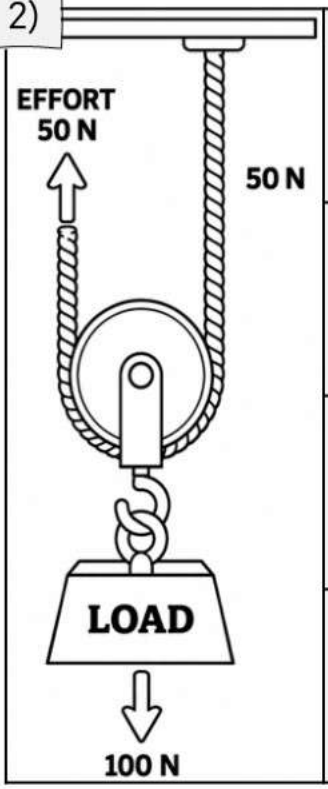
Describe | Describe the forces below.

1)



	Magnitude
	Direction
Point of Application	
Plane of Application	

2)



Magnitude	
Direction	
Point of Application	
Plane of Application	

PREVIEW

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Curriculum Connection
D2.3

Memory Game: Forces and Structures

Objective

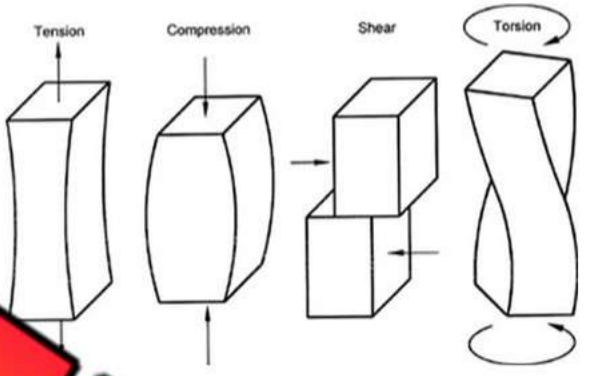
What are we learning about?

To help students identify and remember various forces and structures terms through a fun and engaging memory game.

Materials

What will you need for the activity?

- Memory game cards (provided) with the terms on one set and their definitions on another set.
- A flat surface like a table or the floor to lay out the cards.



Instructions

How will you complete the activity?

1. Divide the class into groups of 3 or 4. Give each group a set of Memory Game cards. (Provided)
2. Have each group lay all the cards face down in a grid on a flat surface.
3. The students take turns flipping over two cards at a time, trying to find a matching term and its definition.
4. If a student finds a match, they remove those cards from the grid and keep them.
5. If the cards do not match, they are turned back over, and the next student takes a turn.
6. The game continues until all the cards have been matched.
7. After the game, review the terms and definitions with the class.
8. Discuss why these terms are important to understand and how they relate to forces and structures.

PREVIEW

Name: _____ 50

Curriculum Connection
D2.3

Cards List of terms and definitions related to forces and structures.

Term	Definition
Frame	A type of structure made up of parts that are joined together.
[illegible]	A type of structure that is strong and hollow, often used to provide support or protection.
Solid	A[illegible]pe [illegible]tructure that is [illegible]ntir[illegible] material, o[illegible]ri[illegible]po[illegible]t[illegible] stability.
Centre of Gravity	The point at which [illegible] weight of an object is evenly balanced in all directions.
Stability	The ability of a structure to remain steady and not fall over.

PREVIEW

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Curriculum Connection
D2.3

Cards | List of terms and definitions related to forces and structures

Term	Definition
Compression	A force that squeezes or presses an object.
Tension	A force that stretches or pulls an object.
Shear	A force that causes parts of a material to slide past each other in opposite directions.
Torsion	A force that twists an object.
Internal Forces	Forces that act within the materials that make up a structure.

PREVIEW

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Curriculum Connection
D2.3

Cards | List of terms and definitions related to forces and structures

Term	Definition
External Forces	Forces that act on a structure from the outside.
[illegible]s	The internal resistance of a material to deformation.
Structural Fatigue	[illegible] of a material [illegible] repeated [illegible] loading.
Structural Failure	The loss of a structure's ability to support a load.
Load	The weight or force that is applied to a structure.

PREVIEW

Name: _____ 53

Curriculum Connection
D2.3

Cards | List of terms and definitions related to forces and structures

Term	Definition
Magnitude	The size or amount of force.
Poin[illegible]licat	The specific location where a force is applied on a structure.
Plane of Application	Th[illegible]irec[illegible]n which a force ap[illegible]structure.
Efficiency	The ability of a st[illegible]re to use materials and resources effectively to achieve its purpose.
Elasticity	The ability of a material to return to its original shape after being stretched or compressed.

PREVIEW

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Describing Magnitude – Newtons

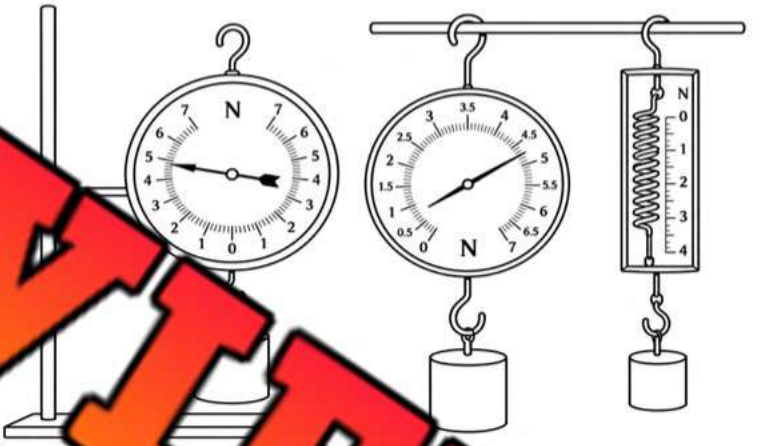
Measuring Magnitude - Newtons

We describe the magnitude of a force using newtons (N). A **newton (N)** is the standard unit for force. One newton (N) is a small magnitude of force, just enough to stretch an elastic band. 10 N is a force that could lift a 1 L bottle of pop. 500 N could lift something that was 50 kg or 110 lbs!

Newtons a[illegible] Kilograms

There is a [illegible]ship between the amount of force (N) needed to lift something in kilogram[illegible] 1kg of mass we want to lift, we would need to apply 9.8 N of force[illegible]te amount of force needed, we can round that to 1 kg = 10 N of for[illegible]eded.

This only [illegible]tin[illegible] object becaus[illegible]e an o[illegible] friction will create [illegible]er f[illegible] acts on the object.



We can use a spring [illegible] measure how many Newtons [illegible]eed[illegible] to lift something. As shown in the pict[illegible] a spring scale has a hook on the bott[illegible] that we can attach a load to. It also has a display or scale that shows us the magnitude of force in Newtons that is pulling dow[illegible]e. [illegible] scales on the left show objects applying a force of 5 N. The spring [illegible]he ri[illegible]ows a smaller object producing 3 N of force.

Common Magnitudes of Force

Force in Newton (N)	Description of the Force
1 N	1) The force needed to lift a smartphone
50 N	2) Average force needed to break the shell of an egg
720 N	3) Average force of a human bite
9000 N or 9 kN	4) The bite force of one adult alligator
16 500 N or 16.5 kN	5) The bite force of an average sized crocodile
100,000 N or 100 kN	6) The average force applied by a seatbelt to a restrained passenger in a car that hits a barrier at 100 km/h
890,000 N or 890 kN	7) The maximum pulling force of a large truck

PREVIEW

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Curriculum Connection
D2.3

Questions

Use information from the text to support your answer.

1) What is a Newton? What does it tell us?

2) What is a spring scale? How do they work?

PREVIEW

Convert

How much force was needed to lift the following objects? (multiply mass by 10)

	Object		Newtons (N)
1)	Smartphone	kg	
2)	Bowling Ball	5 kg	
3)	Boxer Dog	30 kg	
4)	Couch	200 kg	
5)	Average Mid-Size Car	1300 kg	

True or False

Circle whether the statement is true or false.

1) The force needed to slide something is the same needed to lift something.	True	False
2) We can measure the force needed to lift something with a spring scale.	True	False
3) A spring scale measures the force used to lift something in kilograms.	True	False
4) Force is measured in pounds.	True	False
5) Force is measured in Newtons (N).	True	False

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Curriculum Connection
D2.3

Exit Cards

Cut Out Cut out the exit cards below and have students complete them at the end of class.

Name: _____ Mark

Circle the correct answer.

1) What unit is used to measure force?	Newton (N)
	Kilogram (kg)
2) Which force has the greater magnitude?	50 N
	500 N
3) What tool can measure force in newtons?	Spring scale
	Thermometer
4) About how much force lifts a 1 kg mass?	10 N
	100 N
5) Which requires more force to lift?	Smartphone
	50 kg object

Name: _____ Mark

Circle the correct answer.

1) What unit is used to measure force?	Newton (N)
	Kilogram (kg)
2) Which force has the greater magnitude?	50 N
	500 N
3) What tool can measure force in newtons?	Spring scale
	Thermometer
4) About how much force lifts a 1 kg mass?	10 N
	100 N
5) Which requires more force to lift?	Smartphone
	50 kg object

Name: _____ Mark

Circle the correct answer.

1) What unit is used to measure force?	Newton (N)
	Kilogram (kg)
2) Which force has the greater magnitude?	50 N
	500 N
3) What tool can measure force in newtons?	Spring scale
	Thermometer
4) About how much force lifts a 1 kg mass?	10 N
	100 N
5) Which requires more force to lift?	Smartphone
	50 kg object

PREVIEW

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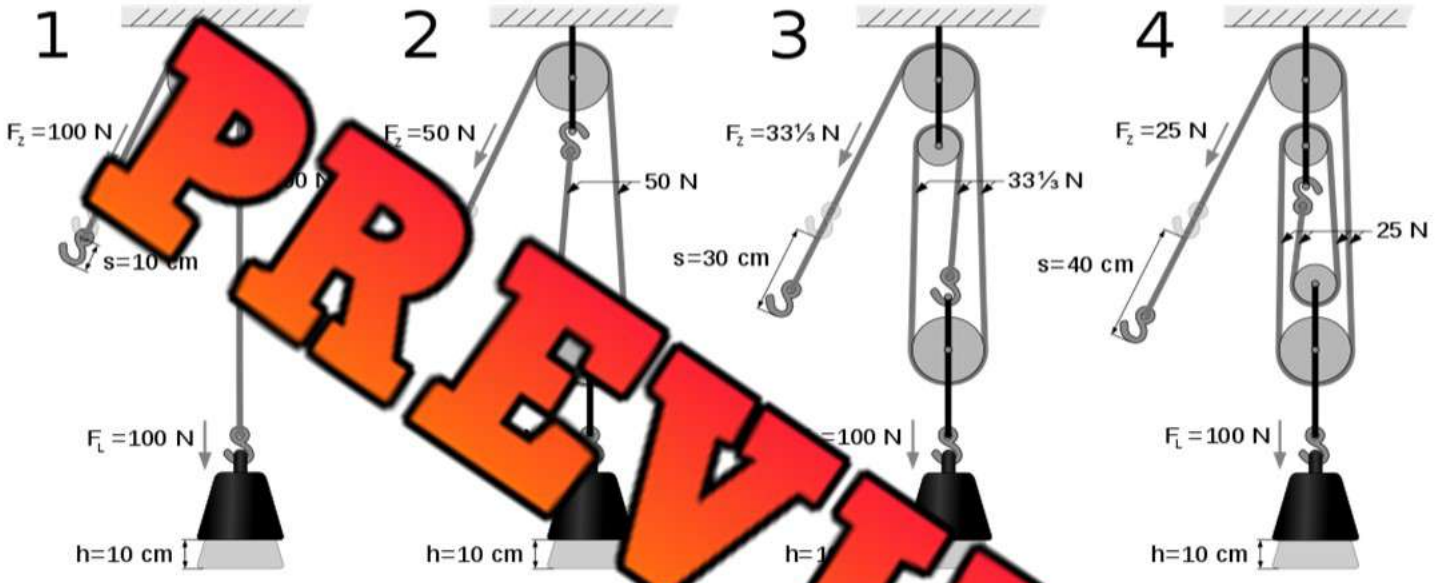
Curriculum Connection
D2.3

Pulley System – Forces/Distance Ratios

Force and Distance Ratio
Using a pulley system allows for a mechanical advantage to make a load easier to move. When we add a pulley, it changes the amount of force you need to apply into the pulley, however, it also changes the distance you need to pull. In the diagram below, the differences between using 1 pulley compared to 2, 3, and 4 are outlined.



PREVIEW

Questions Fill in the table below and answe[r] [q]uestio[ns]

Number of Pulleys	Load	Force Required	Di[stance] to Pull (cm)
1	100 N		
2	100 N		
3	100 N		
4	100 N		

1) What do you notice happens to the relationship between force required and distance to pull when you add a pulley?

_____

_____

2) When would you use extra pulleys? When would just one pulley be enough?

_____

_____

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Curriculum Connection
D2.3

Force Diagrams

What is a Force Diagram?
A **force diagram** is a simple picture that shows the magnitude and direction of a force using arrows. Force diagrams help engineers to understand what forces will act on a structure. If they can predict the net forces acting on all sides of the structure, they will know how strong to make the structure.

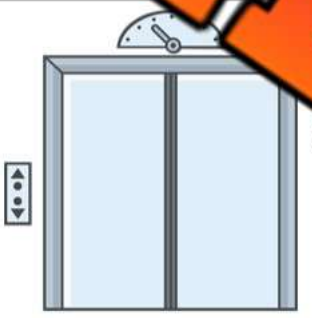
To read a force diagram, you need to understand the following:

- A circle or rectangle represents the object on which the force acts on.
- The length of the arrow shows the strength of the force. The longer the arrow, the stronger the force.
- The direction of the arrow shows the direction of the force

PREVIEW

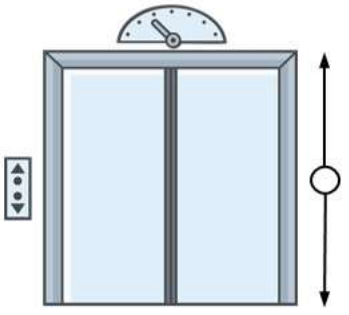
Questions Look at the arrows in the force diagrams and answer the questions.

1)



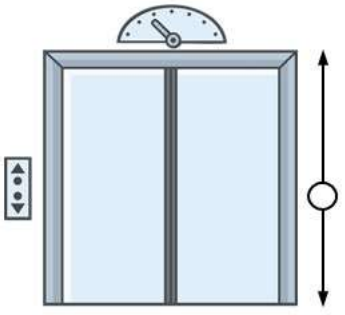
Will the elevator go up or down? Will it be fast or slow? Explain.

2)



Will the elevator go up or down? Will it be fast or slow? Explain.

3)



Will the elevator go up or down? Will it be fast or slow? Explain.

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Name: _____ 60

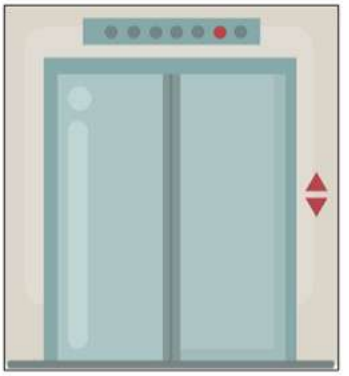
Curriculum Connection
D2.3

Questions Draw arrows to complete the diagrams that represent the situation.

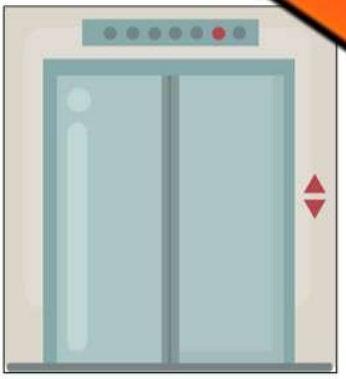
1) An elevator goes down really fast



2) An elevator goes up slowly



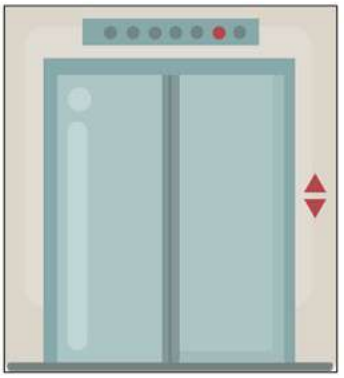
3) An elevator is not mo



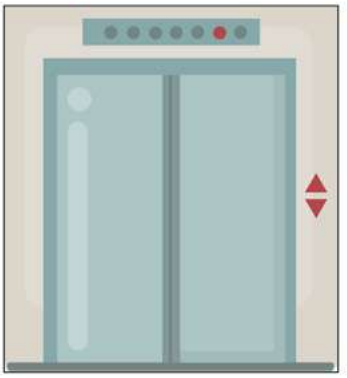
4) An elevator goes down slowly



5) An elevator goes up very slowly



6) An elevator loses its upward force.



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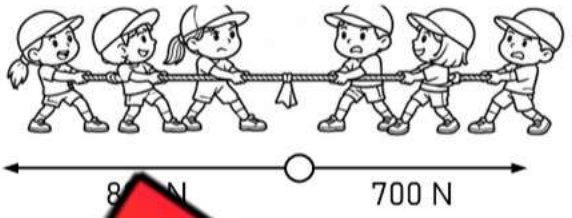
Curriculum Connection
D2.3

Questions Examine the force diagrams and answer the questions.

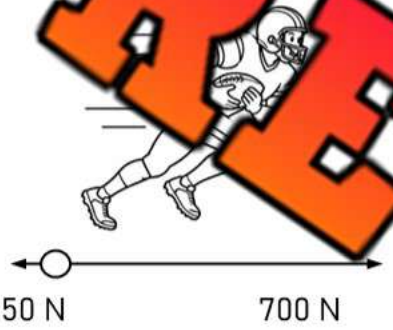
1)



Who will win? Explain how you know.

What is the net force for the team on the left?

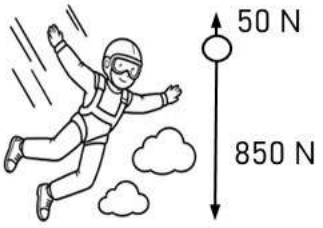
2)

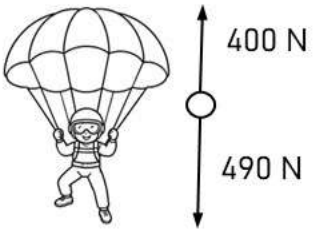


Which direction is the player moving and how fast will he go? Explain.

What is the net force for the player?

3)





When the skydiver is falling, what is happening with the forces between them?

When they release the parachute, what forces are acting on them now? Are they moving?

What is the net force during the free fall?

What is the net force after the chute is released?

PREVIEW

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Name: _____ 65

Curriculum Connection
D2.3

Structural Efficiency

What is Structural Efficiency?

Structural efficiency refers to the ability of a structure, such as a building, bridge, or other man-made structure, to withstand external loads and forces while using the least amount of material possible. Structures that are structurally efficient use materials efficiently and effectively, which can lead to cost savings and reduced environmental impact.



In designing a structurally efficient structure, engineers must consider the loads that the structure will be subjected to (such as snow and earthquakes), the materials that will be used, and the geometry of the structure. The plan should be to use as little mass as possible in your building materials to hold the amount of mass the structure needs to hold.

Calculating Structural Efficiency

We can calculate the structural efficiency of structures by using the following ratio:

$$\text{Structural Efficiency} = \frac{\text{Maximum Mass Supported}}{\text{Mass of the Structure}}$$

An ant is a natural structure that has a high structural efficiency. They can carry 50 times their own mass. An average ant weighs 2-milligrams. This means they can carry 100 mg, which is 50 times its mass. Therefore, an ant has a structural efficiency of 50.

Lasha Talakhadze is a 5 times world champion weightlifter. He has a mass of 183 kg. He can lift and support 274.5 kg over his head. Therefore, he has a structure efficiency of:

$$Structural\ Efficiency = \frac{274.5}{183}$$

$$Structural\ Efficiency = 1.5$$

For a structure like a bridge, an efficient value of 1.0 is good. This means the bridge can support the same mass it is made of.

PREVIEW

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Curriculum Connection
D2.3

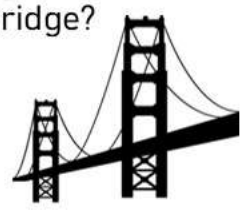
Questions Use information from the text to support your answer.

	Mass of Structure	Mass Structure Can Support	Structural Efficiency
1	200 kg	400 kg	
2	50 kg	75 kg	
3	100 g	250 g	
4		140 T	
5		531.25 T	
6		652.5 kg	
7	1.25 T	T	
8	8 000 kg		
9	50 g		4
10		250	2.5

PREVIEW

Questions Answer the questions below.

1) The Golden Gate Bridge has a mass of 804 672 tonnes. It can support 1 1 tonnes. What is the structural efficiency of the bridge? Is it a structurally efficient bridge?



2) The glass people can walk on in the CN Tower can support 17 500 kg. If the glass has a structural efficiency of 17.5, then how much mass is the glass made of?



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Curriculum Connection
D2.3

Structures Built to Withstand External Forces

Structures Built to Withstand External Forces
Depending on where you live, the structures around you will experience a variety of external forces from weather phenomenon. Strong winds and rain from powerful storms will destroy structures that have not been built to handle these forces.

Rainfall and Flooding
When buil a home that needs to handle a lot of rainfall, the home builder will use eaves to funnel the rainwater away from the house. Eavestroughs are like can sides of the roof that wrap around the house. When rainwater hits the r do to the eavestroughs and th rough out which sends the water awa ous



Floodin when gets a lot of rainfall, and roun orb the water anymore. It a ppen coastal regions when the vels and overflow onto the land. Te nba some engineers will build floating ho at sit on top of the water. They will also house at ar evated on pillars, so the houses aren't affected by the flooding under

Hurricane
A **hurricane** brings strong tornado winds that devas s tha 't built strong enough. The heavy rains cause flooding that also s h mes need to be built out of strong materials in order to have a chanc hurricane.



Concrete is one of the strongest materials that should be used in building a home. Homes built out of concrete have a much better chance at withstanding the forces of a hurricane when compared to those built with wood, brick, or paneling. Steel is another great material that is built to last.

Builders should also use storm windows and hurricane shutters. When a window breaks, the wind and storm can now enter the house and destroy everything inside. Windows are the weakest point because they are made of glass versus the rest of the house being made from a stronger material like wood or steel. A broken window will often allow flooding to enter the home which destroys possessions.

PREVIEW

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Name: _____ 68

Curriculum Connection
D2.3

Questions

Use information from the text to support your answer.

1) How can you build a structure to handle rain and flooding?

2) How sh structure be built in a region that experiences hurricanes?

PREVIEW

Making Connections

Wh t doe ading remind you of in your life?

True or False

Circle whether the statement is true or false.

1) A hurricane can produce tornados.	True	False
2) Concrete is one of the strongest building materials we can use.	True	False
3) Brick and wood houses can easily withstand a hurricane.	True	False
4) Eavestroughs keep rainfall away from our houses.	True	False
5) Windows are the weakest point on a house.	True	False

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Name: _____ 74

Curriculum Connection
D1.1, D2.4

Symmetry in Structures

What is Symmetry in Structures?

Symmetry is when a structure is made up of the same parts so that one side is the same as the other side. Structures built with symmetry could be split using a line of symmetry. On both sides of the line of symmetry, the structure would be the same. Remember, a structure is multiple parts or elements puts together to make something complex. When we put the same parts together in a repeated pattern, the structure becomes more unified, as opposed to randomly put together.



Why Use Symmetry in Structures?

Engineers will design structures symmetrically so that they are stronger, and to make them more aesthetically appealing.

Strength of Symmetry

Symmetrical structures are more stable. Forces that act on a symmetrical structure are balanced. For example, when we sit on a chair, the force of our weight acting on the chair is balanced through all 4 legs because the chair is symmetrical. Imagine the chair was asymmetrical, with different leg lengths. When we sit on the chair, it will wobble, and our weight could be concentrated on one leg instead of being balanced on all four. The chair could collapse as our force might be too strong for just one leg.

When a structure is symmetrical, it is easy to determine its center of gravity (CG). For a symmetrical structure, we can easily determine where the CG is. When engineers understand where the CG is, they can create stability for the structure.

Symmetry = Aesthetically Pleasing



Aesthetics is the study of beauty, attractiveness, and taste. Scientists have discovered that the human brain prefers symmetrical structures over asymmetry. Symmetry gives us a sense of balance, which is calming and more appealing.

The idea of symmetry in structures has been used for many years. The Taj Mahal was built in 1631, and it emphasizes the use of symmetry in structures.

PREVIEW

Name: _____ 75

Curriculum Connection
D1.1, D2.4

Questions

Use information from the text to support your answer.

1) Why are symmetrical structures often more stable than asymmetrical structures?

2) Why are symmetrical structures more aesthetic? Why is that important?

PREVIEW

Making Connections

Draw a structure you know well. It is symmetrical? Explain.

True or False

Circle whether the statement is true or false.

1) Asymmetrical structures allow forces acting on it to be balanced.	True	False
2) Symmetrical structures are more aesthetically pleasing.	True	False
3) It is easier to find the centre of gravity in asymmetrical structures.	True	False
4) The Taj Mahal is a symmetrical structure.	True	False
5) My school is symmetrical.	True	False

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Curriculum Connection
D1.1, D2.5

Structural Failures – Bad Foundation

What is a Foundation?

The **foundation** of a structure is its base that supports the building and anchors it to the earth. The foundation of a building is critical to its stability. If the foundation fails, the building will lose its stability, and will likely cause a structural failure, or collapse.



Building Foundations

The foundation of a building is like the roots for a plant. The deeper or stronger the roots are for a plant, the taller or bigger the plant will be. The same thing is true for structures.

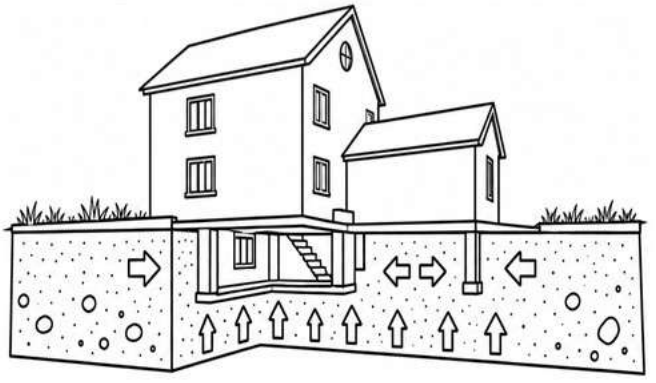
In Canada, we have seasons that cause freezing and thawing of our structures. Engineers must consider how climate will affect the structures they are building.

The building code in Canada requires that the foundation of a structure needs to be 150mm (6 inches) below the local frost line. A **frost line** is the maximum depth underground that the soil will not freeze during the coldest temperatures of the year.

The local frost line will vary, depending on the area of Canada you live. For example, to build a deck in Ottawa, you need footings at least 60 inches because the frost line is 54 inches. In the warmer climate of Alberta, BC, you only need to dig 18 inches as the local frost line is 12 inches.

Basements – Great Foundations

With the frost line in Canada being between 2 and 8 feet, most people building a house decide to build a basement as well. If they are already building a foundation below the frost line, they usually build the basement full depth around 8 feet.



Having a basement means the foundation of the home is definitely built deep enough. Freezing and thawing will not be a problem and the house's foundation will not fail due to temperature changes.

Did you know that in warmer climates, houses do not have basements? In places like Florida, the frost line is very close to the surface, so home builders often don't bother with the extra expense of building a basement. They still dig a foundation below the frost line, but it might only be 1 or 2 feet underground.

PREVIEW

Name: _____ 80

Curriculum Connection
D1.1, D2.5

Questions

Use information from the text to support your answer.

1) Why is a foundation important in structures?

2) Why do houses in Canada have a basement? Why don't houses in Florida?

PREVIEW

Diagram

Draw a house with a basement, draw a garage, draw foundation walls underneath (check frost line). Explain your diagram.

True or False

Circle whether the statement is true or false.

1) A basement should be built right at the frost line.	True	False
2) Houses in warmer climates need basements for strong foundations.	True	False
3) Most houses in Canada have a basement.	True	False
4) It is building code to dig your foundation 6 inches below the frost line.	True	False
5) The frost line is different depending on where you live.	True	False

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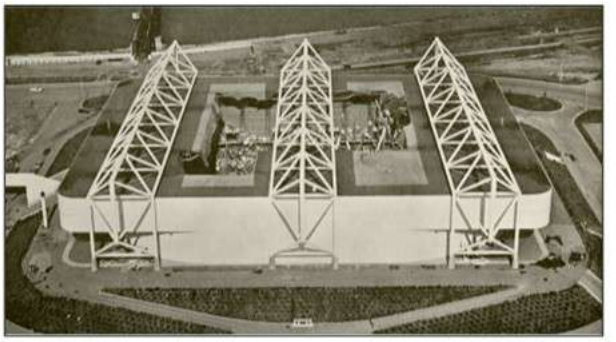
Curriculum Connection
D1.1, D2.5

Structural Failures – Bad Designs

Bad Designs

Sometimes, architects get caught up in having innovative designs that draw attention instead of sturdy structures that will last forever. There is a balance, as many structures with innovative designs get more visitors, which ends up paying off for the owner of the building. Bad designs cause 40-60% of all structural failures.

Kemper Arena – Kansas City, Missouri



In 1979, th[illegible] million new home for the Kansas City Kings [illegible]m was complete. Helmut Jahn was the [illegible] was praised for his innov[illegible]th[illegible]ure no seams and no interio[illegible]umns t[illegible]st[illegible] spectator views. Instead, he use[illegible]lor[illegible]ce frames to support the ro[illegible]i[illegible] was th[illegible]s of concrete and steel[illegible]ning [illegible]ns. Jahn won an Honour Award from the American Institute of A[illegible]ch[illegible] his v[illegible]

The flat roof was bu[illegible]ase r[illegible]radually through undersized drains. But on June 4, 1979, an intens[illegible]-sto[illegible] [illegible]r 10cm of rain on to the roof. The drainage system was too slow, and wat[illegible]d at [illegible] of the drainpipes. The uneven distribution of water led to the [illegible]ward f[illegible]t[illegible] water becoming too strong over top of the drainpipes.

Along with the heavy winds, the pooling [illegible]er br[illegible]ded a force too strong for the roof. The forces caused the fractur[illegible]f [illegible]e[illegible] that held up the roof. When ev[illegible]lt out[illegible]ee snapped on each truss, the ro[illegible] be[illegible]ong for the other 2 bolts to suppo[illegible]t.



Part of the roof collaps[illegible] rubble to the ground. Fortunately, the aren[illegible]empty, so no one was hurt. To fix the roof, the c[illegible]t was approximately $1 million, which in today's day is approximately $4 million.

Lessons Learned

The main forces acting on an outdoor structure will always be environmental – wind, water, and vibrations from the earth. For a structure to last a long time, they need to be able to withstand the worst wind, rain, and earthquake that has been experienced in that region.

When the roof was rebuilt, the drainage down spouts were built much larger to stop water from pooling. Also, a backup system was created where if one part of the roof failed, the force acting on it would be transferred to another part of the roof. Once the issues were corrected, the arena was re-opened in 1980.

PREVIEW

Name: _____ 85

Curriculum Connection
D1.1, D2.5

Questions
Use information from the text to support your answer.

1) Why did the Kemper Arena roof collapse?

2) Why is it important to understand the forces of the strongest rain, wind, and earthquake in a region before you build an outdoor structure?

PREVIEW

Reflect
Why do architects innovate? Is it worth it to potentially create an unstable structure? Explain your opinion.

True or False
Circle whether the statement is true or false.

1) Kemper Arena was an innovative arena that had no interior columns.	True	False
2) The architect built the arena understanding how rain would runoff.	True	False
3) The building's poor drainage system caused pooling on the roof.	True	False
4) Jahn used backup systems in case one part of his structure failed.	True	False
5) The failure in Jahn's building cost Kansas City $1 million.	True	False

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Name: _____ 88

Curriculum Connection
D1.1, D2.5

Structural Failures – Extraordinary Loads

Extraordinary Loads

Our environment sometimes presents extreme conditions that lead to structures being stressed by extraordinary loads. An **extraordinary load** is one that is not within the range of expected loads for a region.

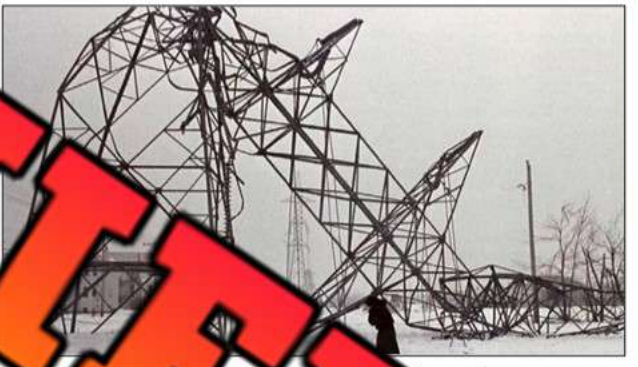
For example, in Canada, we do not experience earthquakes like Japan does. Over a 10-year period, Canada will have approximately 3 earthquakes over a 5.0 magnitude. In Japan, t will experience 89 earthquakes with a magnitude of over 5.0 in that same 10-year p is is because Japan is positioned along the Ring of Fire, an area where s plates meet.

need to be built to withstand the shifting earth caused by earthq s. In C a have other extraordinary loads, like snow piling on roofs. Japan would n stru res to be able to withstand loads from snow. The regions are di ich me raordinary loads are different for each region.

PREVIEW

Ice Storm 1998

In 1998, southern Quebe astern O were pelted with as much a lim freezing rain and ice pellets. Th ed t million residents in Quebec and more e million Ontarians to be left without elec city.



The region received more ice rain in 5 days than they expected for 2 years. This concentrated amount of ice rain and pellets led to ex ry loa tructures. The failing structures, including downed power lines, bi s, a lap d roofs caused massive infrastructure problems.

The ice storm resulted in 35 deaths. The causes of death inc monoxide poisoning, trauma from falling structures, fire, and hypo ern

Over 30,000 utility poles fell, and more than 1,000 giant hydro py collapsed. These structural failures led to approximately 4.5 million people to be without electricity. Without electricity, many people had no heat, no water, and no appliances – stove, microwave, or fridge.

Lessons Learned

The ice storm of 1998 was a once in a century storm that produced extraordinary loads. Not all structures can be designed to withstand the forces of such an event. However, Canadians learned to minimize the impact of a storm like this by having backup plans in place.

For example, the effects of the storm were felt strongest in Quebec because their power grid is above ground. After the storm, money was spent to bury lines to prevent another massive power outage.

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Curriculum Connection
D1.1, D2.5

Questions
Use information from the text to support your answer.

1) What is an extraordinary load? Are extraordinary loads the same in every region?

2) Is it eas[illegible]n engineer/architect to plan for an extraordinary load? Explain.

PREVIEW

Summarize
What happe[illegible]th[illegible]n 1998?

True or False
Circle whether the statement is true or false.

1) An extraordinary load in Canada is different than one in Japan.	True	False
2) Extraordinary loads can cause structures to fail.	True	False
3) All structures need to be prepared to handle extraordinary loads.	True	False
4) It is expensive to create structures that can handle extraordinary loads.	True	False
5) Burying power lines will help minimize the damage from another ice storm.	True	False

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Curriculum Connection
D1.1, D2.5

Exit Cards

Cut Out Cut out the exit cards below and have students complete them at the end of class.

Name: _____ Mark

Check the facts about the structural Failures.

☐ An extraordinary load is outside the normal expected loads for a region.

☐ Every region experiences the same types of extraordinary loads.

☐ Heavy ice can place extraordinary loads on power lines.

☐ The 1998 ice storm caused power lines and structures to collapse.

☐ Structures never need to consider local weather conditions.

☐ Backup plans can reduce the effects of extraordinary events.

☐ All structures can be designed to survive every extraordinary load.

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☐ All structures can be designed to survive every extraordinary load.

PREVIEW

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Name: _____ 91

Curriculum Connection
D1.1, D2.5

Structural Failures – Faulty Construction

Faulty Construction

When structures are not built properly, they have a higher probability to fail. In fact, faulty construction is the second most common reason for structural failure.

The Skyline Plaza Apartment Building, Virginia, US



Overview

A design [illegible]ed by an engineer/architecture team that [illegible] of the $200 million apartment building. [illegible] March [illegible] a portion of the massive 26-story apart[illegible]b[illegible]ng col[illegible] during construction. The collapse began [illegible] 23[illegible] [illegible] 24th story cement slab floor was be[illegible]

The 23rd floor began crac[illegible] whi[illegible] running vertically along the full height of the building, including the bas[illegible] and fou[illegible]. The incident led to the death of 14 construction workers and the injury of 34 oth[illegible]

Why Did It Collapse?

After the collapse, a team of specialists determined tha[illegible] wings [illegible] sign plan had no problems. The problems began as the construction team b[illegible] the [illegible]

The main problem was that the construction crew did not let t[illegible] long enough before building on top of it. They did not properly test the curing o[illegible] cement, which is required when using cement.

Result

The loss of life associated with this structural failure led to a massive investigation. The investigation concluded that the contractor and engineer on site were at fault. They were both found guilty in court of negligence. The contractor did not follow the building code requirements and the engineer did not properly inspect the work.

The extra costs associated with fixing the building was estimated at approximately $20 million.

PREVIEW

Name: _____ 92

Curriculum Connection
D1.1, D2.5

Questions
Use information from the text to support your answer.

1) How does faulty construction cause the failure of structures?

2) What ha[illegible]ed with the Skyline Towers collapse?

PREVIEW

Evaluate
What might happ[illegible]ido[illegible]u[illegible]if you used finishing nails vs screws.



True or False
Circle whether the statement is true or false.

1) When a structure is built, the design and construction are both important.	True	False
2) The Skyline Towers had a poor design.	True	False
3) The Skyline Towers had a good design but faulty construction.	True	False
4) Members of the construction crew were found guilty of negligence.	True	False
5) Using the wrong building material can lead to faulty construction.	True	False

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Name: _____ 100

Curriculum Connection
D1.1, D2.6

Choosing The Right Building Material

Choosing the Right Building Materials

When building something at your home, it is important to choose your building materials wisely. You will want to consider the price, availability, look, and durability of the materials you choose. You may also want to consider if the building material leads to sustainability in our environment.



Price

One of the [illegible]things builders look at is the price of a material. Most projects have a budget. To [illegible]ob done on budget, a building material that is affordable needs to be chosen. [illegible]ding material that is priced within your budget that doesn't comp[illegible]nu[illegible]uality is important. For example, wood is a cheaper building option [illegible]metal [illegible]l strong and durable.

Availability

When building so[illegible], it is i[illegible]o know if the materials you choose are readily available. If you choo[illegible]ma[illegible]ut of stock, you may not be able to repair the structure at a later da[illegible]e is an[illegible] your order and you need more material, it may take longer to ship the[illegible]l fr[illegible]source if it is harder to find.

Look – Aesthetics

When you are building something, you [illegible]under[illegible]w it will look in its final destination. A log cabin in a cottage setting would l[illegible]great[illegible]downtown Toronto, not so much. Also, in some neighbourhoods, the[illegible]some[illegible]about the look of structures. For example, a Homeowners Associati[illegible]ng that the exterior of a house must be red brick.

Durability

Some building materials will last a lot longer than others. If you pla[illegible]ture for a long time, choosing building materials like concrete, steel, wo[illegible]l help.

Sustainability

If you are buying a building material that is manufactured in China, you must understand that the amount of energy needed to get that material to your house in Canada is high. Therefore, a lot of carbon emissions will be produced to receive the material.

Also, you could choose a building material that is better for the environment. Wood can be recycled easily, but logging can lead to deforestation. Cement is also criticized for emitting a lot of CO^2 in the heating of the ingredients and with the chemical reaction that occurs when cement is made.



Bamboo is a very sustainable building material as it grows very fast, so its supply can regenerate quickly. Stone is also a good choice as it is found underground and emits less pollutants than the manufacturing of other building materials.

PREVIEW

Name: _____ 101

Curriculum Connection
D1.1, D2.6

Summarize

Summarize each heading by paraphrasing the important information.

Price	
Availability	
Aesthetics	
Durability	
Sustainability	

PREVIEW

Making Connections

Have you ever built something (skateboard ramp, birdhouse)? What materials did you choose? Why did you choose them?

True or False

Circle whether the statement is true or false.

1) Cement is a very sustainable building material.	True	False
2) Bamboo is a sustainable building material.	True	False
3) Price is an important factor when deciding a building material.	True	False
4) Some HOA's have rules against using certain building materials.	True	False
5) Price is more important than durability when choosing a building material.	True	False

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Curriculum Connection
D1.1, D2.6

Exit Cards

Cut Out Cut out the exit cards below and have students complete them at the end of class.

Name: _____

Mark

Match each the region to the correct description.

Availability	❑ How well the material lasts over time
Aesthetics	❑ How the material looks in the finished structure
Durability	❑ How the material and its use affect the environment
Sustainability	❑ How easily the material can be found or replaced

Name: _____

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Sustainability	❑ How easily the material can be found or replaced

PREVIEW

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Name: _____ 103

Curriculum Connection
D1.1, D2.6

Manufacturing a Product – Choosing Materials

If you owned an athletic shoe company, What materials would you use to make a basketball shoe? Choose based on the cost, shipping, performance, aesthetics, and durability scores below. Scores are out of 10 with 10 being the best option and 1 being the worst. A score of 10 in terms of price means it is the least expensive, so its scores the best.

Options What materials would you use? Choose 1 material from each category.

PREVIEW

Insole					
Mat		Shipping	Performance	Aesthetics	Durability
Foa		9	5	4	7
Gel			8	9	5
Cork			3	6	10
Carbon Fibre	1	1	10	10	10

Ou Botto					
Materials	Price	Shipping	P ance	etics	Durability
Rubber	10	10			8
Leather	2	5	1	8	1

Lacing					
Materials	Price	Shipping	Performance	Aesthetic	Durability
Cotton	7	5	8	8	7
Nylon	3	6	10	10	10
Polyester	10	10	7	5	4

Upper – Rest of the Shoe					
Materials	Price	Shipping	Performance	Aesthetics	Durability
Leather	3	6	2	8	10
Mesh	6	8	9	9	4
Fabric	8	7	7	7	7

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Curriculum Connection
D1.1, D2.6

Target Customer

Who is this basketball shoe for? Is it high end or for beginners?

Choices

Which options did you choose for your basketball shoe?

Insole	
Bottom	

Discussion

Why did you choose for your basketball shoe? Explain.

Diagram

Draw your shoe and label the materials you used.

PREVIEW

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Name: _____ 107

Curriculum Connection
D1.1, D2.6

Beams and Trusses

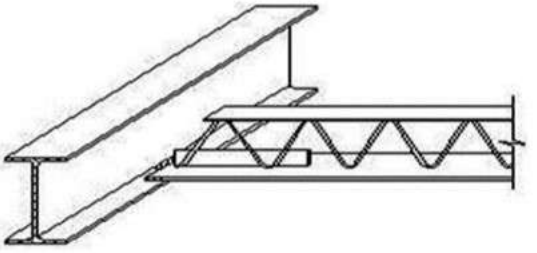
Stable Structures

A structure that does not topple over when forces act on it must be designed and built with certain structural features that give it strength. Engineers need to understand the forces that will act on the structure.

When building bridges, houses and other structures that must withstand live loads, engineers use steel beams and trusses to create stable structures.

PREVIEW

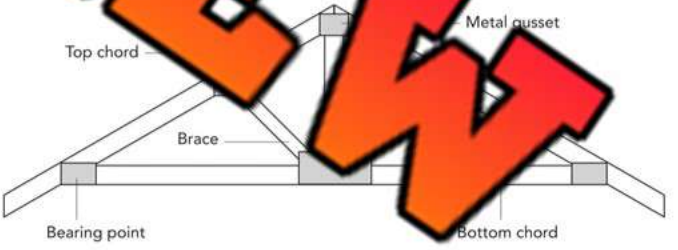
Steel Beams



A **steel beam** is often referred to as an I-beam or H-beam and is a type of structural steel structures. The design and shape of the beam make it capable of handling extreme forces, especially compression.

Engineers use the I-beam for horizontal and vertical purposes to frame in heavy structures like buildings and bridges. Steel beams may bend under extreme forces, but it will not break or buckle. It is an expensive material that is used in commercial buildings and large bridges. They are not commonly used in houses.

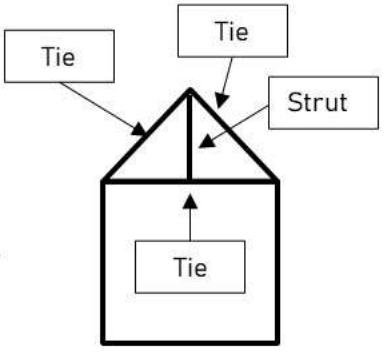
Truss



The truss is a frame that is used to make stable structures. A truss takes advantage of triangles as the triangle is the strongest shape. Triangles are the strongest shape because when a force is applied to a triangular shaped structure, it is spread through all three sides.

Houses use trusses for their peaked roofs that provide stability throughout the entire frame of the house. Truss bridges also take advantage of the strength of the triangle.

Trusses have struts and ties. A strut is a beam that is under compression while a tie is a beam under tension.



Name: _____ 108

Curriculum Connection
D1.1, D2.6

Question Use information from the text to support your answer.

Why are steel beams used to build strong structures? Why are they not used in houses?

_____

_____

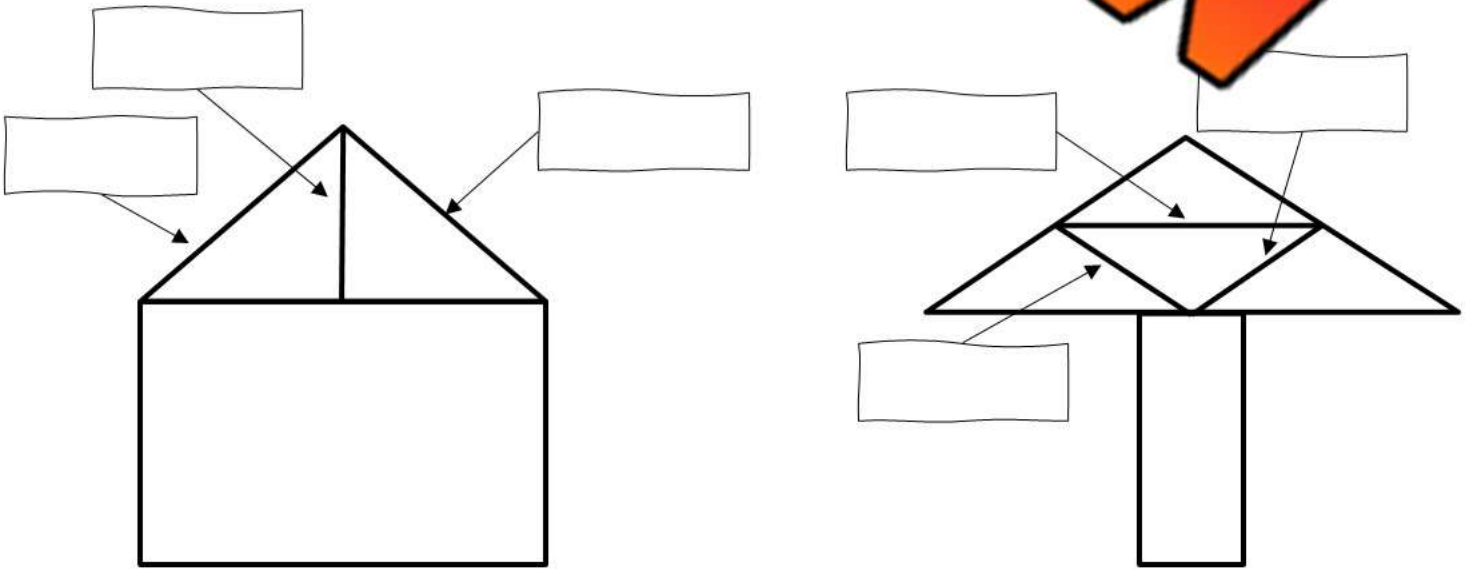
_____

Dra **D** tures of structures that use I-Beams and Trusses.

	Truss

PREVIEW

Diagram Fill in the blanks by labelling the struts es.



Name: _____ 109

Curriculum Connection
D1.1, D2.6

Experiment – Cardboard Beam

Research Question

What are we trying to learn more about?

What is the strongest beam you can make out of cardboard? Which is stronger, a traditional flat beam, an I beam or an X beam?

Materials

What will you need for the experiment?

- C… …ugh to build a beam that will cover a 50 cm span
- Fast…er – g… …e (best), tape
- Cardboard … …rce th… …(to make the I beam or X beam)
- Scissors that ca… …t…
- Weights that you can … …uck… …ing how much load the beam can hold
- A bucket to put the weights in
- A belt or string that you can wrap aroun… …beam … …d in the bucket



PREVIEW

Method

How will you complete the exper…

1) Decide which type of beam you will make – flat, I beam or X bea…
2) Draw a diagram of your beam on the backside of this page.
3) Decide which fastener you will use and how you will fasten your beam together.
4) Ensure your beam will cover a span of 50 centimetres.
5) Begin building your beam.
6) To test the beam, you will wrap a string or belt around the middle of the beam and attach a bucket that you can add weight to.
7) Add the weights until the bridge bends due to the external load.
8) Record how much weight the beam could hold.

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Curriculum Connection
D1.1, D2.6

Planning Answer the questions below.

1) Which type of beam are you going to make? Why are you choosing this beam?

2) What fastener will you use to fasten the materials together? Why this fastener?

3) Draw a diagram of your beam

PREVIEW

Observations What happened? How much load did your beam hold?

Results Why did your beam eventually begin to bend? What internal and external forces caused the structure to break?

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Name: _____ 111

Curriculum Connection
D2.7

Engineers, Architects, Construction Workers

Engineering
An **engineer** is someone who designs structures. An engineer's job is to make sure a structure fills the need of why the structure is being built. For example, if a city needed a bridge to span across a creek, they would get an engineer to design the bridge. The engineer needs to know what loads will be on the bridge so they can choose proper materials and designs.



Architecture
An **architect** is just like an engineer, however, they are more focussed on the appearance of the structure. For example, you may hire an architect to design your house because they will use appealing designs to make your house look awesome. An engineer would be more concerned with making your house strong and not concerned with the appearance.

Construction
A **construction worker** is the person who does the job of carrying out the engineer's or architect's plan. The construction worker builds the structure using the materials that the architect or engineer wants. Without construction workers, engineers and architects would never get anything built!

PREVIEW

Definitions

Explain what the following terms mean.

Engineer	
Architect	
Construction Worker	

Question

Use information from the text to support your answer.

Who do you think has the most important job? Explain.

_____

_____

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Name: _____ 112

Curriculum Connection
D1.1, D2.7

Evaluating Structures – Structural Analysis



Who are Structural Engineers?
Structural engineers work to design, plan, and oversee the construction of new buildings and bridges. They also alter or fix existing structures. A very important part of their job is to ensure their structures are safe and stable for the public to use. I'm s[illegible]u can imagine the pressure associate[illegible]eating a structure that needs to work, as a structure failure could lead to [illegible]

Struct[illegible] Analys[illegible]
Part of a stru[illegible]er's [illegible] is to perform a structural analysis. A **structural analysis** is the [illegible]ation [illegible]ffects that loads will have on the structure they will build. Wh[illegible] en[illegible]s their structural analysis, they focus on investigating the followi[illegible] prope[illegible]f forces acting on their structure.

1) Magnitude – the size o[illegible]ce [illegible]d to the structure
2) Direction – the direction of the fo[illegible] wi[illegible] on the structure. A strong wind would act on the side plan[illegible]e stru[illegible]reas the weight of a heavy snowfall would act downwards, in th[illegible]ectio[illegible]ravity.
3) Position – the position on the structure [illegible]he fo[illegible]. Structural engineers need to understand how every fo[illegible]e [illegible]rt of the structure because the structure might have we[illegible]. A st[illegible]e is only as strong as its weakest point.

When the structural analysis is complete, the engineer wi[illegible]e forces that will act on every part of the structure. Therefore, they ca[illegible]decide what building materials they will use. They can determine the found[illegible] they will use and how they will reinforce parts of the structure they feel is vulnerable to different loads.



Importance of Structural Engineers
Structural engineers have a strong understanding of physics and material science. They have studied how forces act on different materials. They understand the mathematical equations associated with how much force a building material can handle.

Without structural engineers, our buildings, towers, tunnels, and bridges would not be as safe as they are today!

PREVIEW

Name: _____ 113

Curriculum Connection
D1.1, D2.7

Questions
Use information from the text to support your answer.

1) Who are structural engineers? What is their role?

2) What is ...ral analysis? Why is it important to have one before building a structure?

PREVIEW

Questioning
Write 3 questions you ha... ...ding.

1)	
2)	
3)	

True or False
Circle whether the statement is true or false.

1) A structural analysis is only needed for large structures.	True	False
2) A structural engineer builds the structures they design.	True	False
3) Structural engineering is an important job to ensure our structures are safe.	True	False
4) Structural engineers understand physics and material science.	True	False
5) A structure is only as strong as its weakest point.	True	False

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Name: _____ 114

Curriculum Connection
D1.1, D2.7

Structural Assessment Report

What is a Structural Assessment Report?
A **structural assessment report** is an unbiased evaluation of the conditions of a structure. When a structural assessment report is completed, an engineer looks closely at all structural systems in order to determine the condition of the entire building.

When is a ...tural Assessment Report Needed?
When the ...uestions about the stability of a structure, a structural assessment repor... ...ucted. Common reasons for an assessment include:

- Bow... or cr... ...dation
- Settlemen... ...g of a ...g
- Wall cracks
- Sloping floors
- Adding another story to a b...ildin... ...e
- When something is added to a str...ure, like ...r p...s



PREVIEW

Importance of a Structural Assessment Repo...
When buying a building, you may find there was an ...sment co...ed of the building. The report will tell you if there are any conc... ...ut... ...grity of the building. You can trust a structural assessment report be...use ...Ca... ...out by unbiased structural engineers who have the important job o... evaluating every structural component of the building.

An engineer who performs a structural assessment report could be liable for their findings. For example, if an engineer states that a building is safe, if it falls down, that engineer could be charged with negligence because they didn't do their job properly. With that said, if a business owner noticed a structural failure, like a crack in a wall, they need to get it assessed by a structural engineer as they are liable if someone gets hurt in their building.



With so many structures in our communities, it is important that we have structural engineers performing these reports. If we didn't, the structures we use everyday could be faulty, and potentially cause life threatening injuries. Getting our buildings checked regularly means we can feel safe inside structures.

Name: _____ 115

Curriculum Connection
D1.1, D2.7

Questions
Use information from the text to support your answer.

1) What is a structural assessment report? Why are they important?

2) When w call for a structural assessment report?

PREVIEW

Explain
Do you feel more confident in y have been assessed recently?

True or False
Circle whether the statement is true or false.

1) Any construction worker can complete a structural assessment report.	True	False
2) If you see a cracked wall in a building, the owner needs an assessment.	True	False
3) A structural assessment report is done by an unbiased engineer.	True	False
4) We can't trust most structural assessment reports.	True	False
5) Business owners need to ensure their building is safe for customers.	True	False

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Name: _____ 117

Curriculum Connection
A1.3, A1.4, A1.5

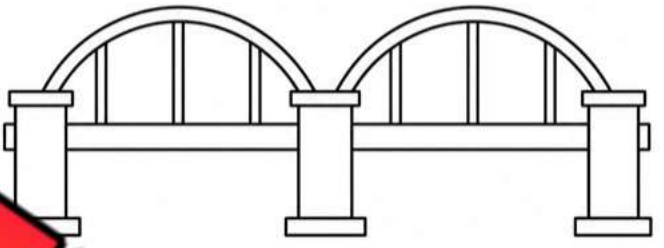
Activity – Building a Bridge #1

Background — What is the activity?

Can you build a bridge using only blocks for pillars and construction paper as the beam? Your bridge will need to support the compressive forces of a toy car crossing t idge. It will also need to support the deadload of the bridge itself.

Mat — hat will you need?

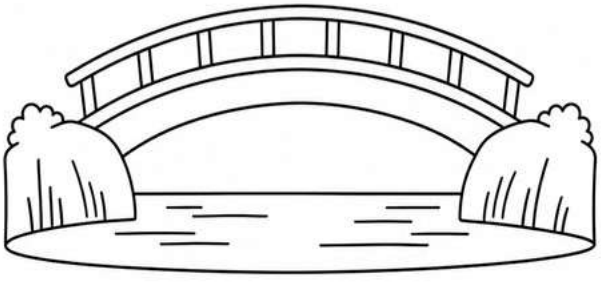
- ✓ 3 blocks
- ✓ 3 sheets of con tio
- ✓ A toy car



Method — How will you comp e expe ?

1) Spend 5 minutes thinking about how you can best use your materials to design a sturdy bridge.
2) Spend 15 minutes building a bridge that a toy car can travel across.
3) The bridge needs to be the length of one piece of construction paper.
4) Experiment with where you put the pillars and how you use the three sheets of paper.
5) Experiment with the type of bridge you use.

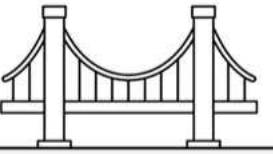




PREVIEW

Name: _____ 118

Curriculum Connection
A1.3, A1.4, A1.5



Observations | What happened?

1) Draw a picture of your bridge below.

2) Was your br[illegible]ful? [illegible]made it successful or unsuccessful?

Results | Answer the questions below.

1) Was your bridge symmetrical? Explain.

2) Did you bridge have a strong foundation?

3) Did your bridge have a high or low centre of gravity? How did this impact its stability?

PREVIEW

Name: _____ 119

Curriculum Connection
A1.1, A1.3, A1.4, A1.5

Activity – Building a Bridge #2

Background — What is the activity?

Can you build a bridge using spaghetti noodles? If you layer the spaghetti noodles, can your bridge support a live load as well as its dead load?

We test how strong your bridge is by increasing the load on the middle of the bridge until it breaks. The bridge needs span a gap of 30cm. Remember, your bridge is only as strong as its weakest part!

PREVIEW

Materials — What you need?

- ✓ Spaghetti noodles – uncooked
- ✓ White glue or hot glue
- ✓ Tape
- ✓ Bucket
- ✓ Belt
- ✓ Weights – we used wooden blocks
- ✓ Marshmallows



Method — How will you complete the experiment?

1) Provide students with time to plan their bridge
2) Have them begin constructing their bridges. Give each group the same number of materials
3) To test their bridges, wrap the belt around the middle of their bridge and around the bucket. Add weights to the bucket until the bridge fails.



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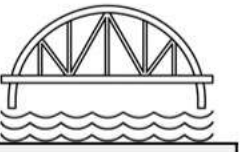
Curriculum Connection
A1.1, A1.3, A1.4, A1.5



Plan | How will you make your bridge?

1) Research some spaghetti bridges online. Choose some ideas you want to replicate and write them below.

_____

_____

_____

_____

2) De... ...ou... ...e will have a...

Strong Foundation	
Low Centre of Gravity	
Symmetry	

3) Draw a plan for your bridge. Label the tape, glue, marsh... ...ws a...

PREVIEW

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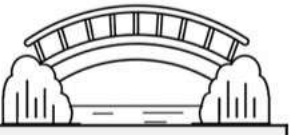
Name: _____ 121

Curriculum Connection
A1.1, A1.3, A1.4, A1.5

Results | How did it go?



1) How successful was your bridge? Explain what happened. Discuss the three concepts you planned on having (symmetry, centre of gravity, foundation).

2) How could you have done better? What would you do differently?

3) Draw the bridge you would build next.

4) How did you bridge fail? What force(s) were too strong for your bridge to support?

PREVIEW

Name: _____ 122

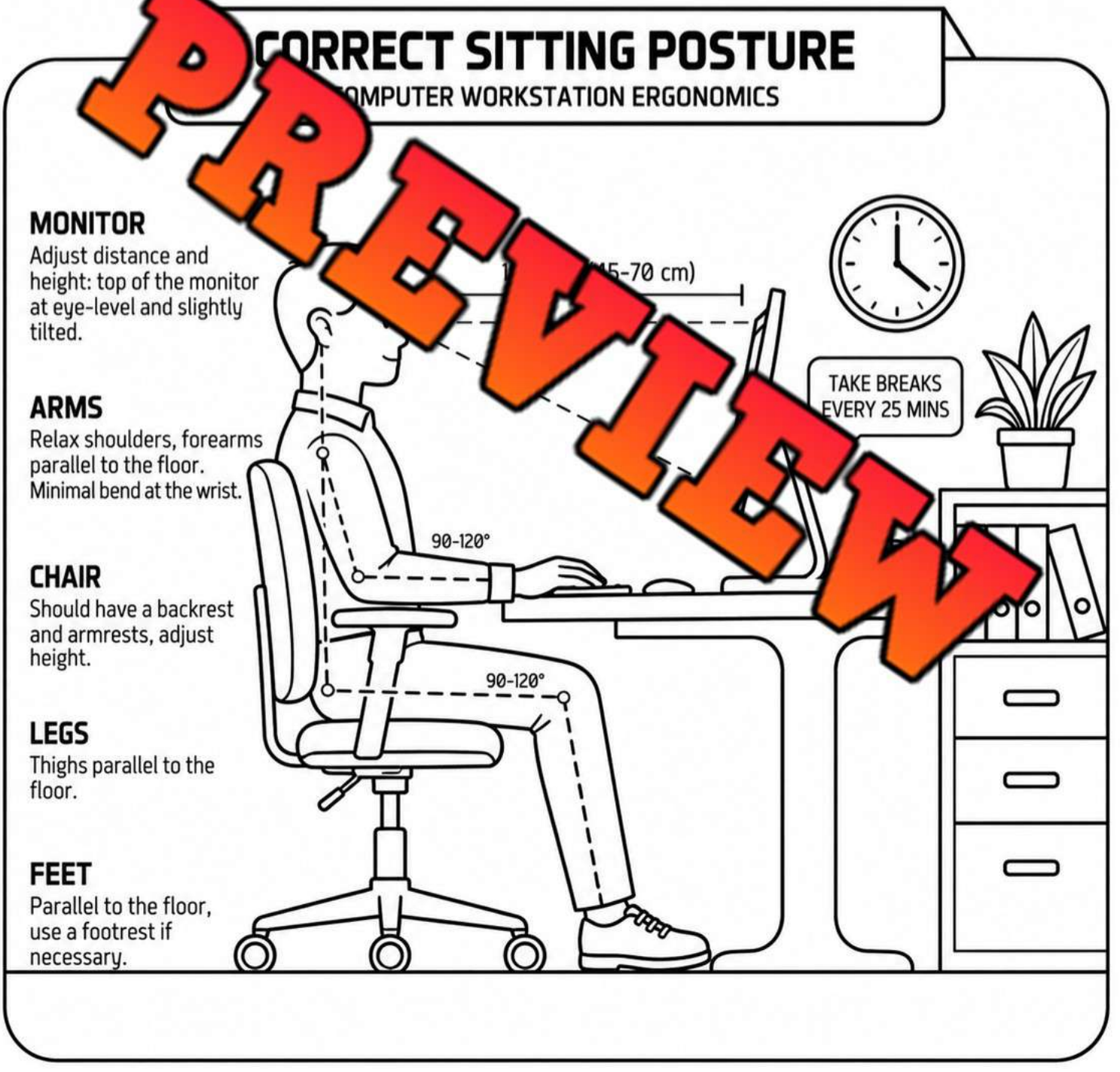
Curriculum Connection
D1.2

Office Ergonomics

Ergonomics is the study of how structures and objects can be arranged and/or designed so that people can use them most efficiently and safely. In an office, ergonomics is the science of creating a workstation that provides a comfortable working environment that maximizes productivity.

Without an ergonomic office environment, common problems include: low back pain, carpel tunnel syndrome, eye strain, and over-use repetitive strain injuries.

PREVIEW



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Name: _____ 123

Curriculum Connection
D1.2

Ergonomic Workstation

Infographic Write six things you can do to have an ergonomic workstation.

1)	
2)	
3)	
4)	
5)	
6)	

PREVIEW

Questions Answer the questions below.

1) What is an ergonomic workstation? Why is it important?

2) How is your posture at your workstation? Evaluate it based on the criteria above.

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Name: _____ 124

Curriculum Connection
D1.2

Assignment – Creating an Ergonomic Workstation

Ergonomic furniture is useful in lessoning the pain of repetitive stress injuries. Ergonomic furniture could be any furniture item – table, desk, or chair – that allows someone to use the furniture without suffering repetitive stress injuries.

Create your own workstation using ergonomic furniture. Your workstation will need the following:



- Desk
- Office
- Co r desktop)
- M
- Key rd

Be creative! W dget, design an ergonomic workstation that allows you to work effici and

PREVIEW

Directions Follow the di s b

1) Research online "ergonomic workstation" t ide your workstation
2) Shop online for the items listed above
3) Copy and paste the items you will buy for your w on. m a PowerPoint, all on one slide. You can rearrange the picture to create your workstation
4) On the next slide, type out the prices for each office supply that you purchased
5) On the 3rd slide, answer the questions below



- Why did you choose each piece of furniture?
- Will you be safe in this workstation, or will you have repetitive stress injuries?
- Will you be able to be productive in this workstation?
- Is this a realistic workstation? Why or why not?

Name: _____ 125

Curriculum Connection
D1.2

Evaluating Ergonomic Workspace

Evaluate Explain the ergonomics in the pictures. What injuries might they sustain? How could they improve?

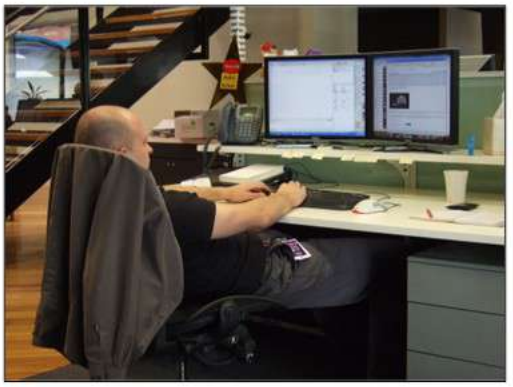
1)



2)



3)



4)



PREVIEW

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Name: _____ 126

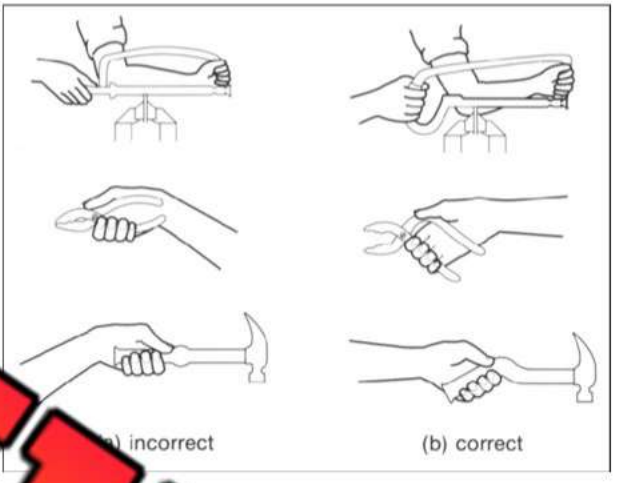
Curriculum Connection
D1.2

Ergonomic Tools

What are Ergonomic Tools

Ergonomic tools are tools designed to let the user perform repetitive motions comfortably without the risk of getting repetitive stress injuries (RSI). Some jobs require the heavy use of the same tools all day long.

Whe rson uses a tool that is not ergonon same motion over and over manner t ventually stress their body. This will pe first time they use a tool, b sev he poor movement will lead to exa you use a box cutter all day, affect you during the first hour, but af al hours of using that same cutter, you will feel fati you if it isn't ergonomically designed.

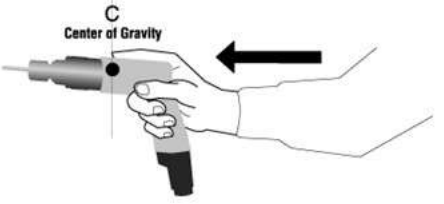


PREVIEW

Ergonomic Hand Tools

The ergonomic design of hand tools can help prevent RSI. Below nic principles applied to hand tools.

- Handle should allow the correct straight wrist alignment – not flexed
- Allowing a healthy thumb position that feels natural
- Provide optimal grasping force so you don't need to overwork
- Use of proper weight for tools so they can be operated with one hand
- Reduce muscular effort to reduce strains
- Centre of gravity should be aligned with the gripping hand so that it is easy to hold in an upright position or in the position it will be used



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Name: _____ 127

Curriculum Connection
D1.2

Ergonomic Tools

Questions Use information from the text to support your answer.

1) Why is it important to use ergonomic tools?

2) How should your body be positioned when operating a tool?

PREVIEW

Ergonomic? Is the use of the tool ergonomic? Explain.







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Curriculum Connection
D1.2

Exit Cards

Cut Out Cut out the exit cards below and have students complete them at the end of class.

Name: _____

Is the statement true or false?

1) Ergonomic tools can help reduce repetitive stress injuries.	T	F
2) A bent wrist is the best position when using hand tools.	T	F
3) Properly designed handles can reduce muscular effort.	T	F
4) Ergonomic tools should require as much gripping force as possible.	T	F
5) A tool's centre of gravity should align with the gripping hand.	T	F

Name: _____

Is the statement true or false?

1) Ergonomic tools can help reduce repetitive stress injuries.	T	F
2) A bent wrist is the best position when using hand tools.	T	F
3) Properly designed handles can reduce muscular effort.	T	F
4) Ergonomic tools should require as much gripping force as possible.	T	F
5) A tool's centre of gravity should align with the gripping hand.	T	F

Name: _____

Is the statement true or false?

1) Ergonomic tools can help reduce repetitive stress injuries.	T	F
2) A bent wrist is the best position when using hand tools.	T	F
3) Properly designed handles can reduce muscular effort.	T	F
4) Ergonomic tools should require as much gripping force as possible.	T	F
5) A tool's centre of gravity should align with the gripping hand.	T	F

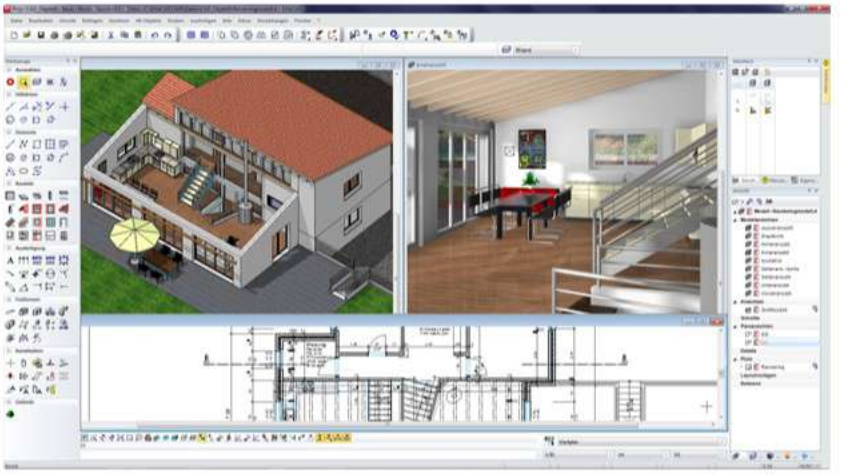
PREVIEW

Name: _____ 132

Curriculum Connection
A2.1, A2.2, A3.1, A3.2, A3.3

Coding – Intelligent Modelling in Construction

Intelligent Modelling



Project managers today use technology to plan building projects and quote prices for these projects. Furthermore, new intelligent modelling is used by c[illegible]uter applications to show h[illegible]ges to a design will affe[illegible]e will cost.

homeo[illegible]r is bu[illegible]w house, they c[illegible]nte[illegible]nt modelling software to make changes to their kitchen. If they [illegible]n gra[illegible]tertops instead of laminate, the intelligent modelling softwar[illegible]inst[illegible]he new price based on the measurements of the countertop and th[illegible], up-t[illegible]prices of the materials.

Intelligent modelling [illegible]ding [illegible]al-time adjustments to building plans. Defined counts are used allo[illegible]n calculations that tell us how our changes to plans affect our price[illegible]

In the scenario above, the user e[illegible]ers the [illegible]e fo[illegible]e of the countertops. The program could be coded for the user to [illegible]e pri[illegible]e building materials, or it could be set to fetch data from [illegible]tab[illegible]line store.

The code for this program could look someth[illegible]e this:

Defined Counts
set [sq footage] of countertops to [200]
set price of [granite] to [$4 per sq foot]
set price of [laminate] to [$2 per sq foot]

[illegible]lam[illegible]ge
print [illegible]
run granite[illegible]ootage
print $800

As you can see, when the user selects laminate, the cost of $400 is printed on the screen. When the user changes the building material to granite, the price changes to $800. This all happens in real-time, instantly to allow project managers to work more efficiently.

This data will be stored as a variable. Perhaps we could name the variable countertops. The value for countertops is now $800, which is a data point that is stored. If the appliances have also been chosen, the variable could be appliances. An intelligent model could add appliances + countertops to instantly give you the total cost for both.

PREVIEW

Name: _____ 133

Curriculum Connection
A2.1, A2.2, A3.1, A3.2, A3.3

Questions Answer the questions below using evidence from the text.

1) What is intelligent modeling? How is it used in construction?

2) How computer technology making building homes more efficient?

PREVIEW

Directions Write defined counts and run code to calculate costs below.

Defined Counts
set [sq footage] of flooring to [ ]
set price of [hardwood] to [$ per sq foot]
set price of [laminate] to [$ per sq foot]

Calculate cost of laminate

Calculate cost of hardwood

Calculate cost of flooring and countertops together (use code from back page).

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Name: _____ 134

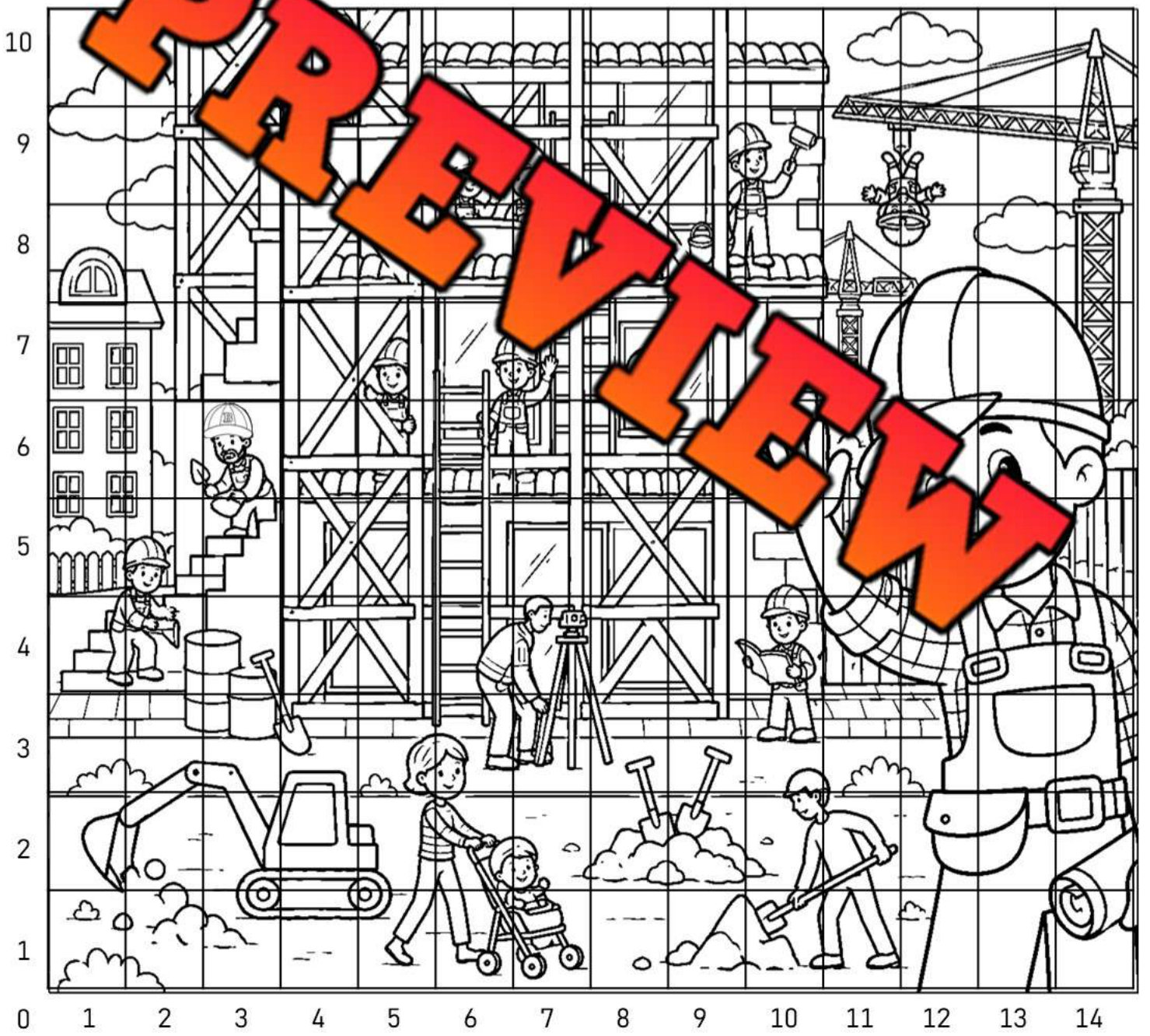
Curriculum Connection
A2.2, A3.1, A3.2, A3.3

Artificial Intelligence Improving Safety

On large construction sites, hundreds of construction workers can be working at the same time. With so many moving parts, it becomes almost impossible to ensure the safety of everyone on site.

Artificial intelligence (AI) is now being used on construction sites to spot dangerous situations. AI can recognize objects based on their shape. With object recognition, cameras around the worksite can spot missing guard rails, places where people might fall, and people not wearing enough personal protective equipment (PPE).

Mapping ere the AI, what safety hazards would you spot below?



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Curriculum Connection
A2.2, A3.1, A3.2, A3.3

Coordinates Write the coordinates and explain the hazard the AI would find.

Coordinates (Choose one coordinate around the middle of the hazard)	**What is the Hazard** 

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Question How is artificial intelligence improving safety on construction sites?

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Curriculum Connection
A2.1

AI Improving Safety At Recess

AI can recognize familiar objects, like people, buildings, and vehicles. Imagine you were tasked to put 4 cameras in your recess area to stop students from getting hurt. The cameras have AI that can detect unsafe behaviours, like jumping from high heights or leaving a fenced area. The codes could look like this:

If student exits [school yard]
THEN sound [alarm]

If student is [2m or more] off the ground
THEN send alert to [teacher device]

IF/THEN [illegible] for the AI cameras on your school property.

If
THEN

If
THEN

If
THEN

If
THEN

If
THEN

If
THEN

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A2.2, A3.1, A3.2

Map Draw a map of your recess area. Label where you would put 4 AI cameras.



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A2.2, A3.1, A3.2

Questions Answer the questions about the AI cameras that will improve safety.

1) What are the unsafe behaviours your AI cameras are looking for?

2) How ca stop these unsafe behaviours?

3) How would using these AI cameras he teacher pri ?

4) How do these cameras work? Could you program in the boundaries of your school yard? Could your cameras detect motion outside of these boundaries? Explain how the cameras could detect other unsafe behaviours.

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Activities – Materials, Failures and Ergonomics



Word Search Find the words from the word bank.

Durability	Strength	Flexibility	Aesthetics	Design
Engineer	Architect	Loads	Faulty	Construction
Symme	Stability	Collapse	Foundation	Disasters

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

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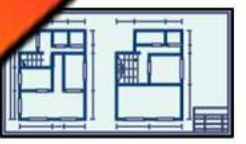

Word Scramble Unscramble the words from the word bank.

GEENINRE		TSYYMMER	
ASOLD		NSTTGHER	
AIBLUTYRDI		RDISEATSS	
EAPLSOCL		HEICARTTC	
CSASETITHE		BTLIELIFXYI	

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Name: _____ Date: _____

Unit Test – Form, Function, and Design

Multiple Choice /10

1) An arena dome is an example of which type of structure? a) Frame b) Shell c) Solid d) None of	2) A hydro dam is an example of which type of structure? a) Frame b) Shell c) Solid d) None of the above
3) A bicy le of which type of struc a) Frame b) Shell c) Solid d) None of the above	4) A bridge with cars driving on it is an example of which type of load? a) Dead load b) Static load c) Total load ive load
5) Sitting on a chair is an examp whi force? a) Torsion b) Tension c) Compression d) Shear	terial is the most durable? a) C er c) St d) Wood
7) If a dog weighed 60 kg on earth, how much would it weigh on the moon? a) 360kg b) 20kg c) 10kg d) 120kg	8) Playing tug of war example of which for a) Torsion b) Tension c) Compression d) Shear
9) Which material is the most sustainable? a) Brick b) Steel c) Nylon d) Bamboo	10) Ergonomic structures allow people to... a) Work longer b) Work more productively c) Have less pain using the structures d) All of the above

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Definitions – What does the term mean (1 mark each) /5

Term	Definition (what does it mean)
Structure	
Ergonomics	
Centre of	
Forces	

Short Answer Question (2 /6

1) How does the centre of gra st its stability?

2) Why is a foundation important? How can we build strong fo dati

3) What does form follows function mean? Why is it important?

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Long Answer (5 marks each) **/10**

1) What can cause a structure to fail/collapse? Choose an example of a structure that has collapsed and discuss what went wrong.

2) How can we build sustainable stru... What ...rials should we use? What other factors should we consider if w...nt to m...e ... structures impact on the environment?

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