Unit D: Form and Function (Pg. 260 – 345)
Chapter 11: Structural Strength and Stability (PB - pg. 242 – 261)

11.1: Stability of Structures (Pg. 245)

1. What is stability?
Stability is a structure's ability to stay balanced when outside forces try to move it.

2. What 3 features make an object stable?
a) Low COG **b) Wider Base** **c) More Support Points**

3. Where is the centre of gravity of:
a) a golf ball? **In the middle of the ball** b) a round doughnut with a hole in the centre? **In the middle of the hole.**

4. When you ride on a bus, are you more stable if you stand or if you sit? Why?
You are more stable if you sit b/c: lower cog, wider support base, more support points.

11.1: Explain COG and Stability (Pg. 246)

1. Read the sentences below. Explain what happens in each situation using the words "cog" and "stability".
a) A van has a heavy load on its roof. The van goes around a curve and falls over.
The van's cog is high above the support base. When the van goes around a curve, it tilts. The cog moves outside the support base, and the van falls over.

b) A man is on a canoe in the water. The man leans over the edge of the boat to look in the water. The boat tips over.
When the man leans over the edge, the cog is no longer over the base of the boat. This causes the boat to tip over.

2. For each pair of objects, circle the object that is more stable. Explain your answers:

A) a bicycle **a tricycle**
A tricycle is more stable b/c is has a lower cog, wider base, and more support points.

B) **a short, fat vase** a tall, thin vase
A short, fat vase is more stable b/c is has a lower cog, wider base, and more support points.

C) **a sled** a scooter

A sled is more stable b/c is has a lower cog, wider base, and more support points.

11.2: Making Structures Strong (Pg. 250)

1. Name two places you have been seen beams in your community.
A beam inn a doorframe. **A cantilever on the diving board at the pool**

2.
a) What is corrugation?
A corrugation is folds or ridges I building materials used to add strength to the structure.

b) Where is corrugation used?
Cardboard boxes and plastic roofs use corrugation.

4. How do ties and struts strengthen beams? (Hint: What forces do they resist?)
Ties and struts support beams by resisting forces. Ties resist tension, and struts resist compression.

11.2: Find Structural Support Solutions (Pg. 251)

Imagine you are an engineer. Circle the structural support you would choose in each situation. Then, explain your answers.

1. You need to design cardboard boxes to hold heavy books and furniture.
   I-beam **corrugation** gusset

Corrugation is a common way to add strength to cardboard.

2. You need to strengthen concrete beams for an office building.
   Rebar cantilever corrugation

Rebar adds support to concrete beams, which are weak against tension.

3. You need to support the beams on a bridge so they can resist compression forces
   Tie **strut** plastic material

A strut adds support below a beam to resist compression forces.

4. You need to design a wooden balcony for a house on a ravine. The ground in the ravine is unstable.
   Corrugation **cantilever** rebar

A cantilever has vertical support at only one end.

11.4: Making Structures Strong: The Truss, Arch, and Dome (Pg. 254)

1. How do trusses help support structures?
Trusses use triangles to distribute force. This helps structures support more weight.

2. Name 3 structures that use trusses.
Ferris wheels, bridges, and roofs use trusses.

3.
a) How are arches and domes similar?
They both transfer compression force downward.

b) How are they different?
An arch transfers force in one plane. A dome transfers force in many planes.

4. Why might an engineer choose to use an arch instead of a beam?
He may want to make a structure that can support a greater load than a beam could.

11.6: Structural Failure (Pg. 260)

1. Why do you think some people use low-quality materials or poor installation when building structures?
They may want to save time and/or money. They may not understand how to install things correctly.

2. Name 3 things that contribute to foundation failure.
a) poor soil **b) earthquakes** **c) poor installation**

4. Why is it important to analyze past structural failures?
Analyzing past structural failures helps people understand how they can design and build better structures in the future.

Chapter 11: Structural Strength and Stability (pg. 288 – 315)

11.1: Stability of Structures (Pg. 290 – 294)

1. Define the followings:

a) Stability: **The ability of a structure to remain in or return to a stable, balanced position when forces act on it.**

b) Centre of gravity: **The point around which an object's mass is equally balanced in all directions; the point where the mass seems to be concentrated.**

2. State the location of the centre of gravity of:

a) A golf ball: **the geometric centre.**

b) A bagel: **the centre of the hole.**

3. What three features of an object provide good stability?

A low centre of gravity, a wide support base, and more supporting points.

4. State the (3) conditions needed for stability.

The centre of gravity must be low, the support base must be wide, and must have more support points. COG must be directly over the support base.

5. Which is more stable? Explain why in each case.

a) A turtle or a giraffe: **A turtle. It has a lower COG**

b) The CN Tower or your school building: **School. It has a lower COG and wider base**

11.2: Making Structures Strong: The Beam (Pg. 295 – 297)

1. How is a cantilever different from a fully supported beam?

A supported beam is supported at both ends. A cantilever is supported only at one end.

2. Define the followings:

a) Beam: **A horizontal structure designed to support a load.**

b) Corrugation: **Multiple folds in a material that provide additional strength.**

c) Cantilever: **A beam supported at only one end.**

d) A tie: **A structural support that is part of a framework and is designed to resist tension forces. It is usually set at an angle between a beam and its support base.**

e) A strut: **A structural support that is placed below a beam where it provides resistance to the forces of compression.**

f) A gusset**:** **Is a flat, plate-like device, often triangular, that supports a beam by reinforcing the connection between the beam and its support base.**

11.4: Making Structures Strong: The Truss, Arch, and Dome (Pg. 300 – 302)

1. List four examples of structures that use trusses.

a) Hydro towers **b) bridges** **c) roofs of homes** **d) The International Space Station**

2. Describe the similarities and differences between arches and domes.

Similarity: They both have an inverted curved shape that directs forces downward.
Difference: Arches have only one plane of application, while domes have many planes of application.

3. Explain how compression forces are different in arches and domes.

An arch directs a compression force downward in only one plane, but a dome directs a compression force downward in many planes at once.

4. Define the followings:

a) Truss: **A network of beams arranged in triangles.**

b) Arch: **A curved structure used to span a space while supporting a load.**

c) Dome: **A shell structure that looks like the top half of a sphere.**

11.6: Structural Failure (Pg. 306 – 309)

1. List four possible causes of structural failure.

1) bad design **2) faulty construction** **3) extraordinary loads** **4) foundation failure**

2. A 12-year-old student sits on a child's tricycle and one of the rear wheels breaks off. What was the most likely cause of the structural failure?

The most likely cause of the failure was extraordinary load. The tricycle was probably designed and tested to support the weight of a small child, but not the weight of a 12-year-old.

Chapter 11 Review: (pg. 314 – 315)

1. Match each definition in the left-hand column with the most appropriate word from the right-hand column:

Definition	Term	Answer (write the term)
a) a beam supported an only one end	Arch	**Cantilever**
b) folding a material repeatedly to provide additional strength.	Rebar	**Corrugation**
c) steel rod used to reinforce concrete	Truss	**Rear**
d) looks like the top part of a sphere	Cantilever	**Dome**
e) a curved structure used to support a load, or make an opening in a bigger structure.	Dome	**Arch**
f) a network of beams that form triangles.	corrugation	**truss**

2. Distinguish between a simple beam and a cantilever. Provide two examples.

A beam is a flat structure supported at both ends. Examples: The upper part of a door frame and a table top.
A cantilever is a beam that is supported at only one end. Examples: Some lookout platforms over gorges and canopies over building entrances.

3.

a) Why are trusses so useful in structures?

Trusses are useful because they provide support, while adding a minimal amount of mass.

b) List three structures that make use of trusses.

Construction cranes, hydro towers, and bridges all make use of trusses.

7. A student is leaning back in a chair. Eventually, the student falls over backward. Explain what happened using the terms "force," "centre of gravity," and "stability."

As the student leaned back in the chair, the student's COG shifted back as well. To have stability, the COG of an object must be over the object's support base. In this case, the support base is the area between the two legs of the chair that are on the floor and the student's two feet. When the COG moved outside the support base, the force of gravity pulled the student down.

8. What are the three factors that can affect a structure's ability to support a load?

The structure's mass, shape, and form.

12. Why is rebar so common in the construction of structures using concrete?

Concrete can withstand a great deal of compression, but it cannot withstand a lot of tension. Rebar helps the concrete resist tension forces.

Worksheet: Stability and COG (Pg. 13)

Part A)

1. B 2. D
3. E; b/c: 1) high COG 2) only 1 support point 3) smaller base
4. D; b/c: 1) lower COG 2) 6 support points 3) wider base

Part B)

1. A 2. D
3. A; b/c: 1) high COG 2) 4 support points; very closet 3) smaller base
4. D; b/c: 1) lower COG 2) 4 support points; very far apart 3) wider base

Part C:

1) Eiffel Tower 2) Pyramid; b/c: 1) lower COG 2) more support points 3) wider base

Part D:

You will fall forward. Your COG will move past your support base causing you to fall...

WS: Review of Structures and Supports: Pg. 133

1. b 2. g 3. j 4. e 5. d 6. h 7. i 8. f 9. a 10. c 11. k