Chapter 2

Force and Machine

2.1 Change in Motion

Lesson 1 Change in Speed

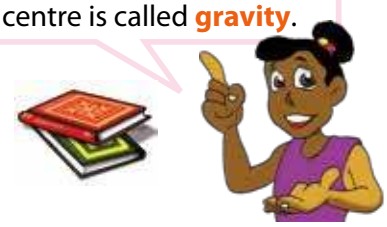
A force can change the speed of an object. How does the speed of an object change when a force is applied?

How does an applied force change the speed of an object?

Activity : Measuring a motion on an inclined plane

What We Need:

- 2 m rain water gutter, marble, stopwatch, books to stack, ruler

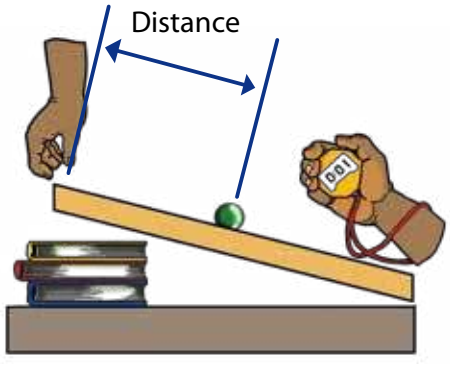


What to Do:

1. Draw a table like the one shown below.

Time (sec.)	Distance (cm) trial 1	Distance (cm) trial 2	Avg.distance (cm)	Speed (cm/sec)
1				
2				
3				

2. Set one side of the gutter on the stacked books to create a ramp.
3. Release the marble from 0 cm and start your stopwatch. Mark the position where the marble reaches for 1 second. Measure the distance and record it in the table.
4. Repeat Step 3. Then take the average of the two distances.
5. Repeat Steps 3 and 4 for 2 seconds and 3 seconds.



6. Calculate the speed of the marble at 1, 2 and 3 seconds.
7. Share your results with your classmate.

Result

We found out that as the marble rolled down the ramp, it speeds up.

Example: Results of activity

Time (sec.)	Distance (cm) trial 1	Distance (cm) trial 2	Avg. Distance (cm)	Speed (cm/sec)
1	19	21	20	20
2	82	78	80	40
3	185	175	180	60

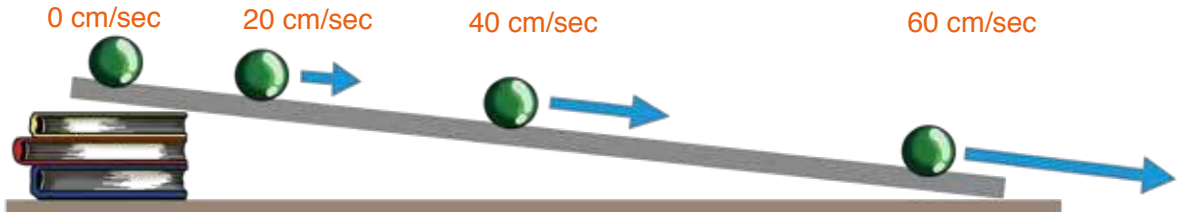
Discussion

Think about the following questions based on your results.

1. What type of force is exerted on the rolling marble?
2. How does the speed of the marble change when the force was applied?

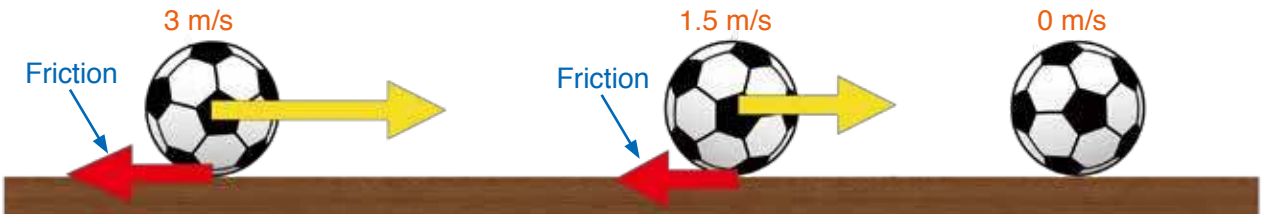
Summary

A force can cause an object to speed up (**accelerate**) or slow down (**decelerate**). For example, **gravity** is the force that pulls one object toward another. When the marble rolls down the ramp, the force (gravity) is always exerted on the rolling marble. As the marble rolls down, it speeds up or increases speed (accelerate).



A marble increases speed as it rolls down the ramp.

Friction is also a kind of force. Friction happens when two surfaces of objects rub against each other. When a ball is rolling on the ground, the force (friction) acts in the opposite direction to the movement of the rolling ball. The ball then decreases speed (decelerate) and finally stops.



A friction makes a moving ball slow down.

Lesson 2 Change in Direction

A force can cause an object to speed up or slow down. What would happen to the direction of a moving object when a force is applied to it?

How does a force change the direction of a moving object?

Activity : Throwing a ball up straight

What We Need:

- a ball

What to Do:

1. Draw a table like the one shown below.

	How does it change?	
	Your prediction	Your observation
Speed		
Direction		

2. Predict how the speed and the direction of the ball change when you throw it up straight into the air.
3. Throw the ball up straight in the air. Observe how the speed and the direction of the ball changes. Record your observations in the table.
4. Share your observations with your classmate. Discuss how a force changes the direction of an object in motion.

Result

We found out that as a ball went up in the air, the ball slowed down and its direction was upward. And then the ball stopped in the air. After that, the ball speeded up and its direction was downward as it fell toward the ground.

Example: Results of activity

	How does it change?
Speed	The speed decreases when the ball goes up. Then it stops (Speed is 0). And then the speed increases.
Direction	The direction is upward when the ball goes up. The direction is downwards when the ball falls towards the ground.

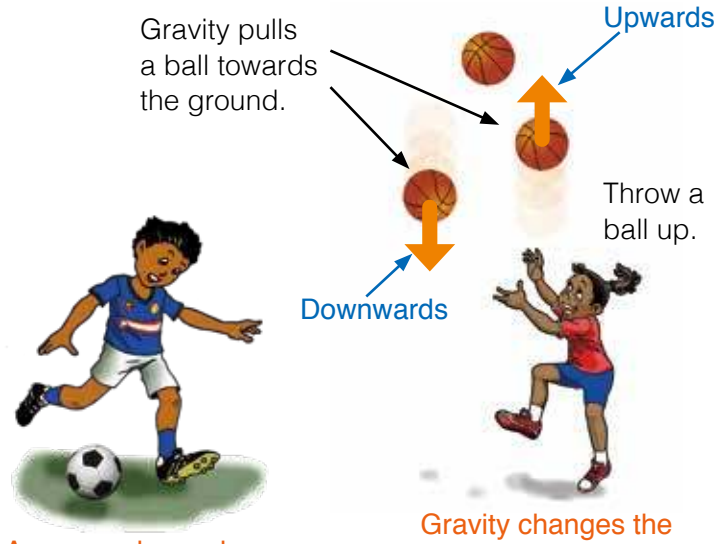
Discussion

Think about the following questions based on your results.

1. What type of force was exerted on the ball after throwing it?
2. How does the direction of the ball change when the force was applied?

Summary

A force can make a moving object change direction. When we throw the ball up in the air, its direction is upward.
But the gravity changes the direction of the ball to be downwards and the ball falls to the ground.
A good soccer player can control the motion of a soccer ball by applying a force that changes the ball's direction.
If we have a yoyo tied to a thread and we just spin it in a circle, the direction of the yoyo changes.



A soccer player changes the ball's direction by kicking the ball.

Gravity changes the direction of a ball.

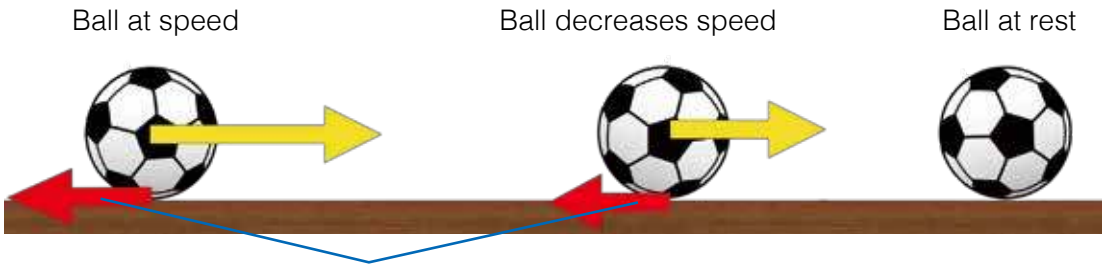
A spinning yoyo tied to a thread changes direction.

Summary and Exercise

Summary 2.1 Change in Motion

Change in Speed

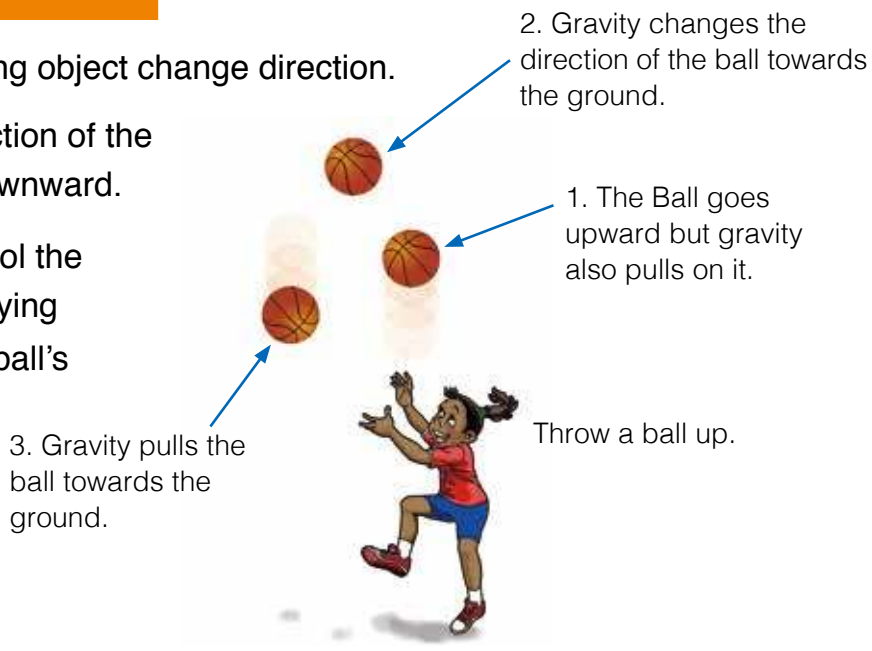
- A force can cause a moving object to speed up (accelerate) or slow down (decelerate).
- Gravity is a force that pulls one object towards another object.
- As an object rolls down a ramp, it increases speed due to gravity.
- Friction is a force that happens when two surfaces of two objects rub against each other.
- Friction always acts in the opposite direction of the moving object. When an object is rolling on the ground, the object decreases speed and finally stops due to friction.



Friction occurs and acts in the opposite direction of the moving ball.

Change in Direction

- A force can make a moving object change direction.
- Gravity changes the direction of the ball moving upward to downward.
- A soccer player can control the motion of the ball by applying a force that changes the ball's direction.



Summary and Exercise

Exercise 2.1 Change in Motion

Q1. Complete each sentence with the correct word.

(1) The force that pulls one object towards another is called _____.

(2) Force that happens when two surfaces rub against each other is called _____.

Q2. Choose the letter with the correct answer.

(1) What happens when the marble rolls down a ramp?

A. It accelerates in speed.

B. It decelerates in speed.

C. Its speed remains the same.

D. It decreases the speed.

(2) Which sentence is true when we throw a ball into the air?

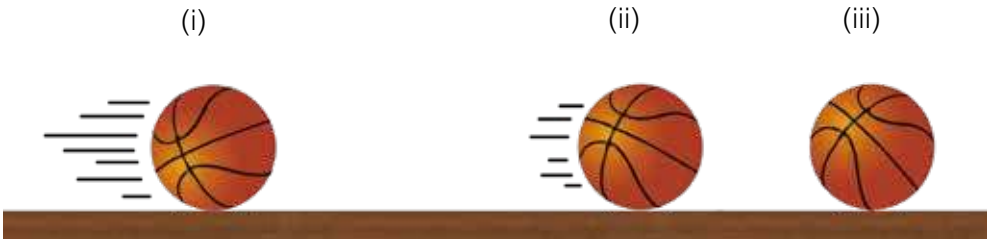
A. The ball does not change its direction when thrown in the air.

B. The ball decreases speed as it falls back to the ground.

C. The speed of the ball is the same when it was thrown in the air.

D. The ball changes direction when gravity acts on it and falls downwards.

Q3. Study the picture and answer the question.



The ball was rolling on the rough ground at position (i) and finally stopped its motion at position (iii). How can you describe the motion of the ball from position (i) to (iii)?

Q4. Mero measured the speed of a moving car every 5 seconds. Look at his record shown in the table on the right. Identify whether the car accelerated or decelerated and explain the reason of you answer.

Time (sec.)	Speed (m/s)
5	10
10	20
15	30

2.2 Regularity of Levers

Lesson 1 Lifting a Load Using a Lever: 1

A **lever** is a simple machine that makes an object move with less force. How can we lift a heavy sand bag with a lever?

How can we lift an object by using a lever with less force?

Activity : Find ways to lift the sand bag easily using a lever

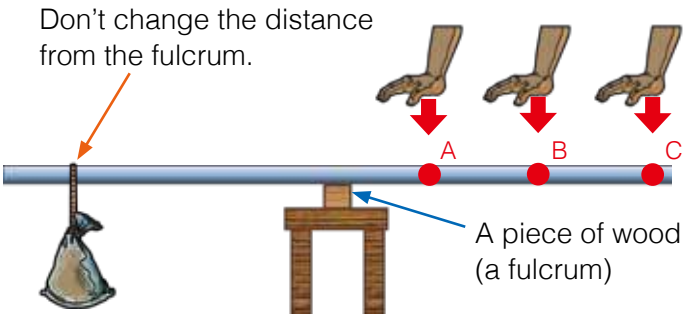
What We Need:

- pole (1.5 - 3 m long), plastic bag with sand, a piece of wood, stool

What to Do:

1. Draw a table like the one on the right in your exercise book.
2. Set up the pole on the piece of wood. Hang the sand bag on one side of the pole as shown in the picture. The distance from the fulcrum to the sand bag should not be changed.
3. Apply force on position A to lift the sand bag.
4. Record how you felt about the amount of force needed to lift the sand bag.
5. Repeat Steps 3 and 4 by applying force at positions B and C.
6. Share your results with your classmates. Discuss the relationship between the distance from the fulcrum and the amount of force applied to lift the sand bag.

Position you applied the force	Amount of force to lift the sand bag (small, medium or large)
A	
B	
C	

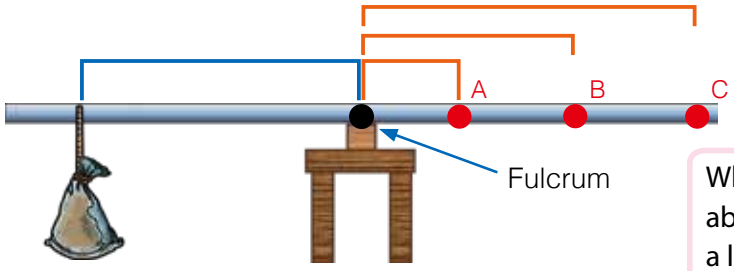


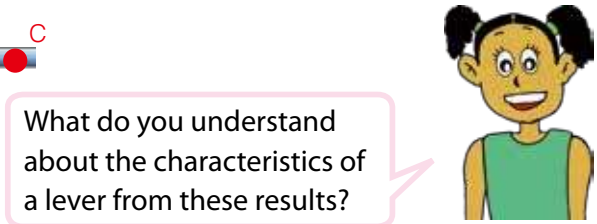
To avoid injury, do not release your hands from the pole suddenly!

Result

We found out that a larger force was needed to lift the sand bag at position A but less force was applied to lift the sand bag at position C when the distance from the fulcrum to the sand bag did not change.

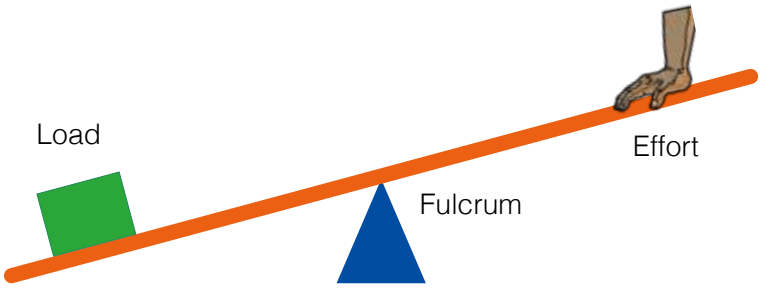
Position you applied the force	Amount of force to lift the sand bag
A	Large
B	Medium
C	Small





Summary

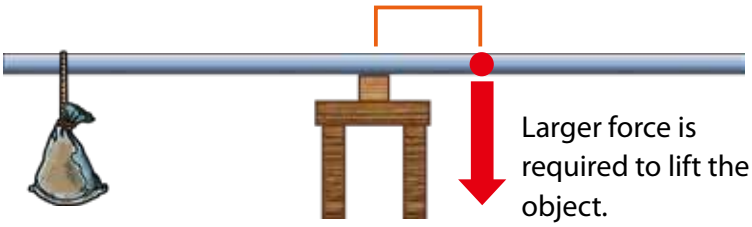
A lever can make our work easier. An **effort** is the force applied to a machine to do work. A **load** is the force applied on the lever by the object to be lifted. Amount of force as an effort required to lift an object depends on its distance from the fulcrum. If effort is applied at a longer distance from the fulcrum, the object is able to be lifted with less effort.



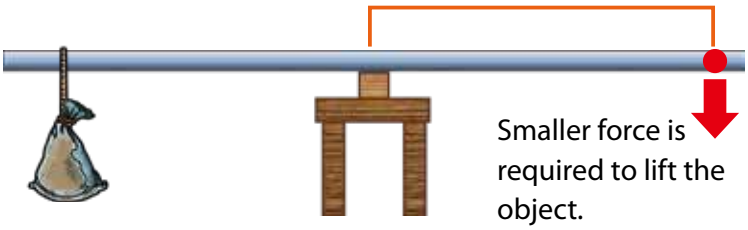
Load, effort and fulcrum of a Lever

Relationship between distance of applied force and load

Shorter distance from the fulcrum to effort point.



Longer distance from the fulcrum to effort point.



Lesson 2 Lifting a Load Using a Lever: 2

We can move an object with less force by applying the force at a longer distance from the fulcrum of a lever. What is another way to lift an object with less force?

How does the distance from a fulcrum to a load affect an effort?

Activity : Changing distance from fulcrum to a load

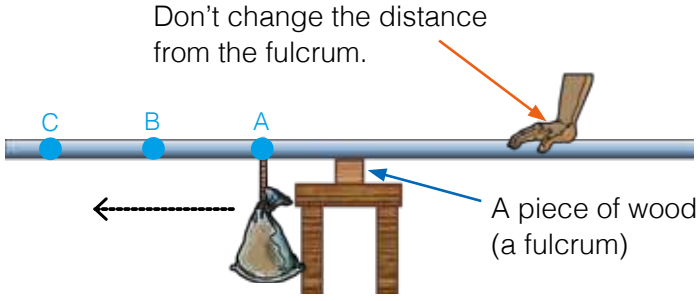
What We Need:

- pole (1.5 - 2 m long), sand bag as a load, stool, piece of wood as a fulcrum

What to Do:

1. Draw a table like the one on the right in your exercise book.
2. Write your prediction to describe the strength of the applied force when the sand bag is lifted at each position.
3. Set up the pole on a piece of wood.
4. Hang a sand bag on position A. Apply force to lift the sand bag.
5. The place where you apply force should not be changed. Record how you feel about the amount of applied force to lift the sand bag in the table.
6. Repeat Steps 3 and 4 by changing the positions of the sand bag from A to B and C.
7. Share your results with your classmates. Discuss how the distance from a fulcrum to a load affects the effort.

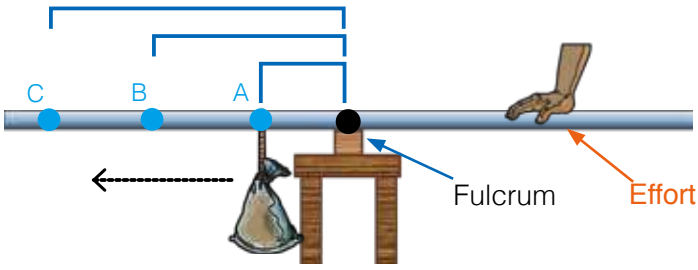
Position of a sand bag	Amount of applied force to lift the sand bag	
	Prediction	Result
A		
B		
C		



To avoid injury, do not release your hands from the pole.

Result

We found out that in position A, a smaller force was needed to lift the sand bag when the distance from the fulcrum to the effort did not change. But at position C, a larger force was applied to lift the sand bag when the distance from the fulcrum to the effort did not change.

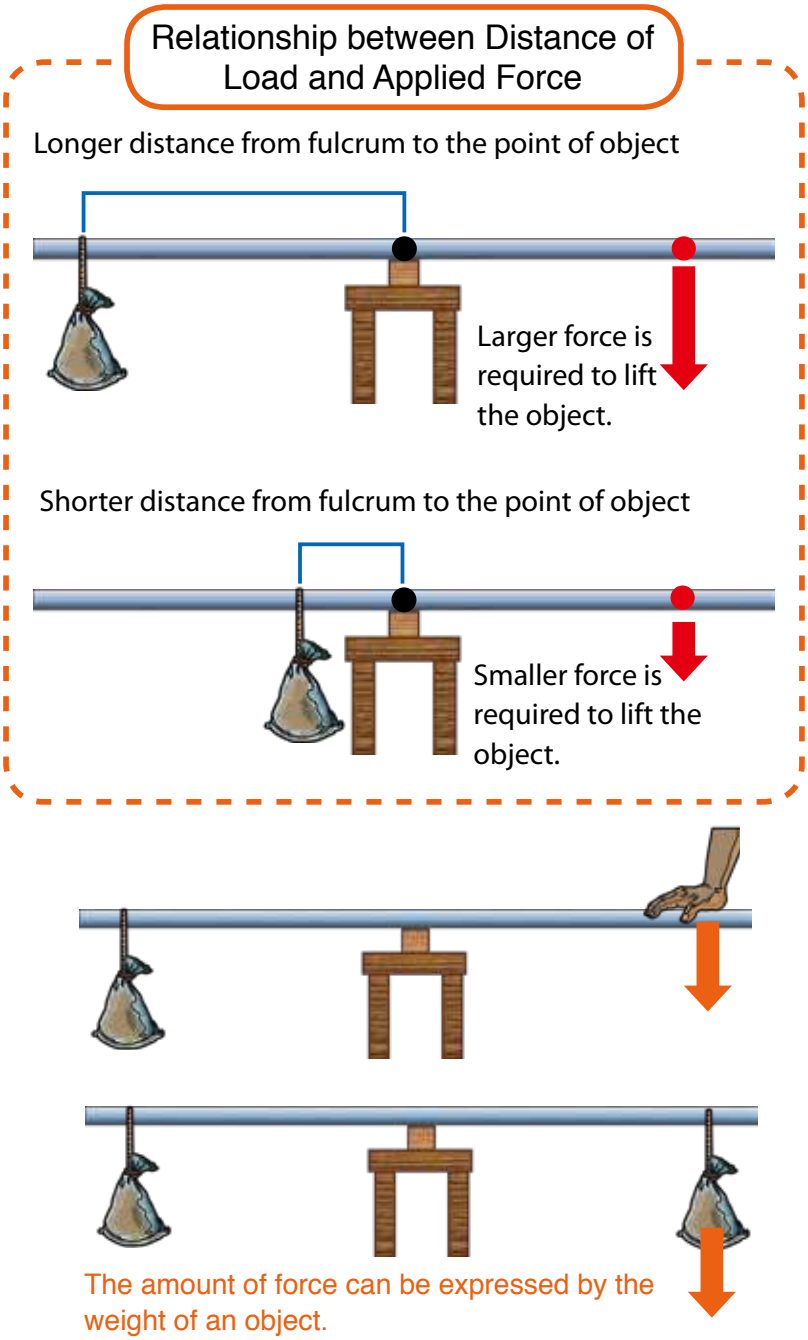


Position of the sand bag	Amount of force to lift the sand bag
A	Small
B	Middle
C	Large

Summary

The amount of force required to lift an object depends on the distance from the fulcrum to the position of the object. If the object is placed at a shorter distance from the fulcrum, the object would be able to be lifted with less effort.

As shown in the picture on the right, we can balance the lever by hanging another sand bag instead of the force applied by your hand. The amount of force can be also expressed by the weight of an object.



Lesson 3 Law of Lever to Balance

Look at the picture on the right. The lever is balanced. What will happen if the position of the weights change?

How can we balance a lever?

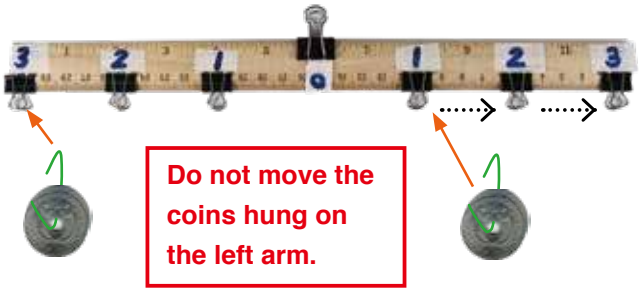
Activity : Finding the rule to make a lever balance

What We Need:

- 30 cm ruler, 7 bulldog clips, 2 paper clips, 8 one kina coins, pen

What to Do:

1. Make a lever by putting a bulldog clip at the centre of the ruler as shown in the picture on the right.



2. Put other bulldog clips on both ends at 5 cm, 10 cm and 15 cm from the centre. Check if the lever is balanced. Label each clip as shown in the picture.
3. Draw a table like the one below in your exercise book.

	Left arm	Right arm		
Distance from the fulcrum	3	1	2	3
Number of coins	2			

4. Hang two one kina coins on the left arm on distance 3.
5. Try to balance the lever by adding a one kina coin every time on the right arm on distance 1. Record the number of one kina coins on the right arm to balance the lever in the table.
6. Repeat Step 5 for distances 2 and 3 on the right arm.
7. Share your results with your classmates.

Result

	Left arm	Right arm		
Distance from the fulcrum	3	1	2	3
as weight	2	6	3	2

We found out that when we hung 6 coins at distance 1, 3 coins at distance 2 and 2 coins at distance 3 on the right arm, the lever was balanced, when we hung 2 coins at distance 3 on the left arm.

Discussion

Based on your results, think about the following question.

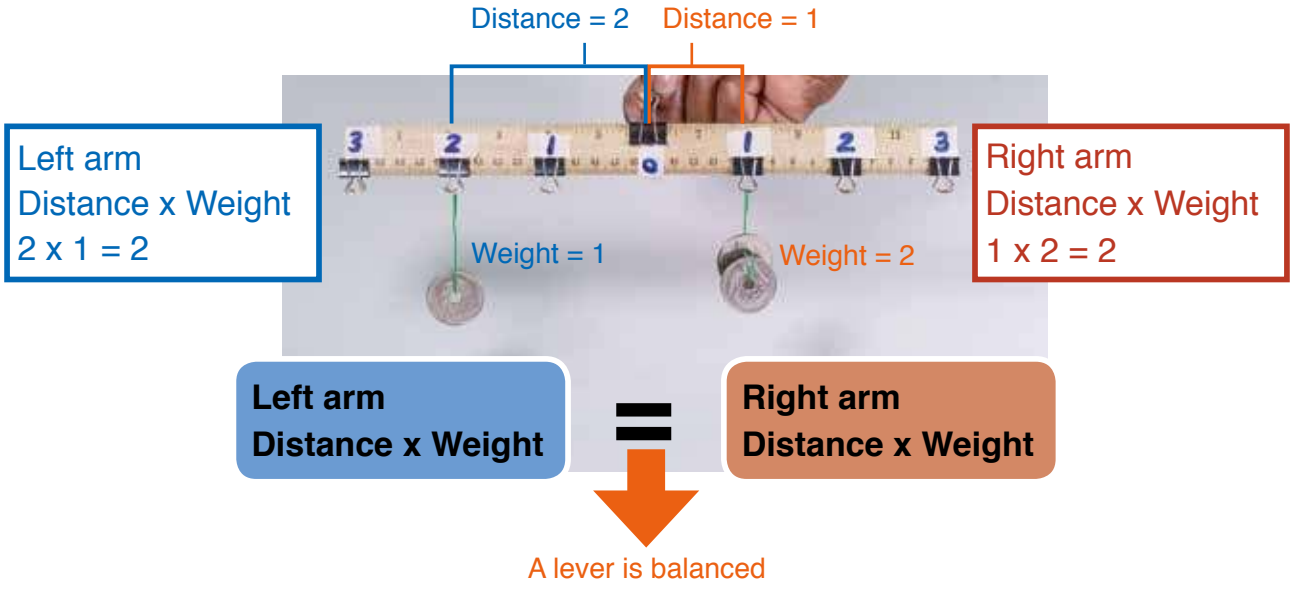
1. What relationship can you find between the distance from the fulcrum and the numbers of coins on the left and the right arm to make the lever balanced?

The sum of the numbers of coins and the distance on left arm (2+3=5) and the right arm (1+6=7) are not equal!

How about multiplying the numbers of coins by the distance from the fulcrum of the lever like….
Left arm: 3 x 2 = 6
Right arm: ????

Summary

A lever is balanced when the product of weights and distance from the fulcrum on the left is equal to the product of weights and distance from the fulcrum on the right arm.



Summary and Exercise

Summary 2.2 Regularity of Levers

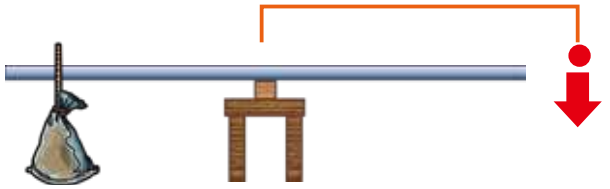
Lifting Load by Using Lever

- A lever is a simple machine that makes an object move with less force.
- The effort is the amount of force applied.
- The load is the force applied on the lever by the object to be lifted.

Lifting Load with Less Effort

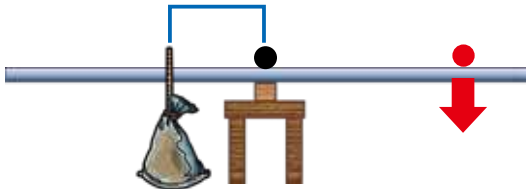
- The amount of force required to lift an object depends on;
  1. The distance from the fulcrum to the effort.
     Lesser effort is needed to lift the load, when the effort is applied further away from the fulcrum.
  2. The distance from the fulcrum to the load.
     Lesser effort is needed to lift the load, when the object is placed at a shorter distance from the fulcrum.

Distance of the effort from the fulcrum is longer



Smaller force is needed

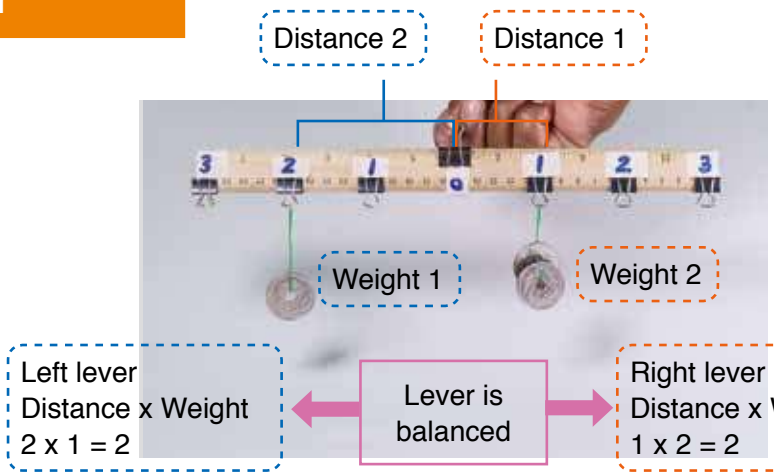
Distance of the load from the fulcrum is shorter



Smaller force is needed

Balancing the Lever

- A lever is balanced when the product of the weight and distance from the fulcrum on the left arm is the same as the one on the right arm.



Summary and Exercise

Exercise 2.2 Regularity of Levers

Q1. Complete each sentence with the correct word.

(1) A simple machine consisting of an arm with a fulcrum is called a _____.

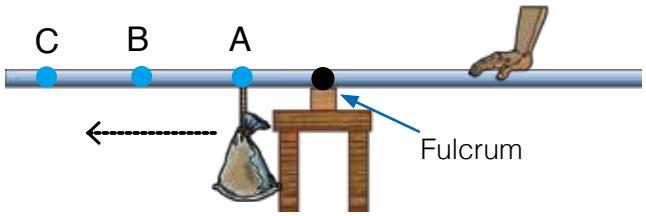
(2) The force applied to a machine to do work is called an _____.

(3) The force applied on the lever by the object to be lifted is called a _____.

Q2. Choose the letter with the correct answer.

(1) Which position of the load on the lever would require less force to lift the object ?

(2) Which position of the load on the lever would require more force to lift the object?



Q3. Answer the following questions.

	Left arm	Right arm			
Distance from the centre	4	1	2	3	4
Number of coins (K1.00 coin)	2				

(1) How many one kina coins would be hung on distance 1 of the right arm to balance the lever?

(2) Four one kina coins were hung on the right arm of the lever. At which distance were the four one kina coins hung to balance the lever?

Q4. Study the picture on the right. A girl and younger boy are playing on a see-saw. The see-saw is balanced. What did the boy and the girl do to balance the see-saw?

LEVERS IN OUR BODY

Levers can be identified by the way the joint and muscles attached to the bone are arranged.

Skull and neck - Nodding your head

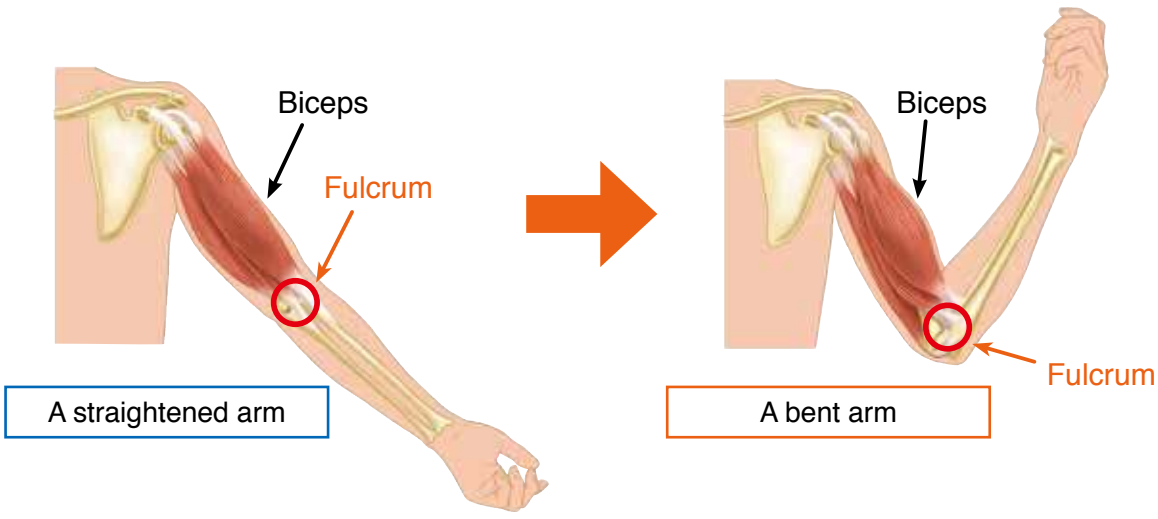
The place where your skull meets the top of your spine is fulcrum. Your skull is the lever arm and the neck muscles at the back of the skull provide the force (effort) to lift your head up against the weight of the head (load). When the neck muscles relax, your head nods forward.

Tip toes - Standing on tip toes

The fulcrum is at your toe joints and your foot acts as a lever arm. Your calf muscles and achilles tendon provide the effort when the calf muscle contracts. The load is your body weight and is lifted by the effort (muscle contraction).

Bent arm – Bending your arm

The fulcrum is at the elbow and the forearm acts as the lever arm. The biceps muscle provides the effort (force) and bends the forearm against the weight of the forearm and any weight that the hand might be holding.



Chapter Test

2. Force and Machine

Q1

Complete each sentence with the correct word.

(1) A force can cause an object to _____ up or slow down.

(2) A force can make a moving object change its _____ and _____.

(3) A force that slows down the movement of an object between two surfaces that touch each other is called _____.

(4) To _____ means that the motion of an object speeds up.

Q2

Choose the letter with the correct answer.

(1) What happens to the speed of an object as it rolls down a slope?
The speed of the object

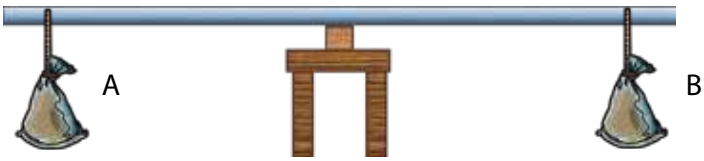
A. remains the same.

B. increases.

C. decreases.

D. decreases then speeds up.

(2) The lever shown below is balanced. The distance from load A to the fulcrum and the distance from load B to the fulcrum are same. Which of the following is true about the diagram?



A. A is heavier than B.

B. A is lighter than B.

C. A and B have different weights.

D. A and B have the same weights.

(3) What is the best reason to explain why a ball comes to a stop after rolling for some time?

A. Because there is no force acting on the ball.

B. Because the ball ran out of force to continue rolling.

C. Because the force of gravity is pulling the ball backwards.

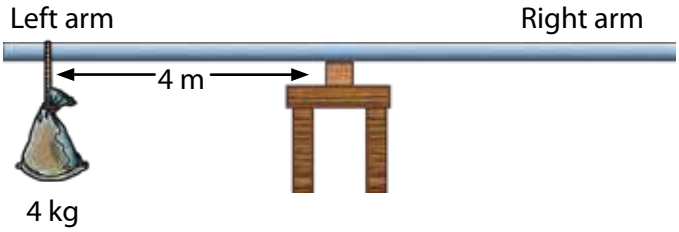
D. Because of the friction force acting between the ball and the ground.

Q3

(1) Study the diagram below.
The ball is moving in the direction to the right. It is decelerating due to friction and will come to a stop. In which direction is the friction force acting on the rolling ball?

_____

(2) If a 4 kg weight was placed on the left arm at a distance of 4 m from the fulcrum:



(i) What is the product of the weight and distance on the left arm of the lever? (Ignore its units)

_____

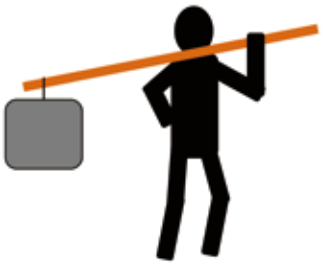
(ii) The lever is balanced when the other weight is hanging on the right arm at the distance of 2 m from the fulcrum. Calculate what would be the amount of weight on the right arm?
Your calculation: _____

_____

Answer: _____ kg

Q4

Kolo wanted to carry a bag of fruits but he struggled to balance the bag on the pole on his shoulder. What must he do to be able to carry the bag on the pole on his shoulder?



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