Unit Topic: Motion and Force

Essential Question: How do forces cause changes in an object's speed and direction of motion?

Concept 1: *Describing Motion*

Objectives:

Describe the motion of objects depicted in graphs.

Analyze and explain distance vs. time graphs.

Vocabulary:

Motion
Reference point
Distance
Displacement
Speed
Average speed
Instantaneous speed
Velocity

Practice:

1. The cross-country team goes on a 10-mile run after school. They end the run outside of the locker room, where they started. Find the distance and displacement of the runners.
2. A family travels 110 km east to spend the night in a hotel. The next day they drive back home, but after travelling 45 km west they decide to stop and visit with friends for the night. Find the distance and displacement of the family.
3. A car drives 215 km west and then 85 km south. Find the distance and displacement of the car.
4. If you ran 3.1 miles in 0.5 hours, what was your speed?
5. Sound travels at 330 m/s. If a lightning bolt strikes the ground 5 m away from you, how long will it take for the sound of the strike to reach you?
6. A man drives south to work every day. If his 55 mile commute usually takes 0.75 hours, what is his average velocity?
7. Sketch the following distance vs. time graphs (you will need 4):
   a. An object not moving
   b. An object moving at a constant speed
   c. An object speeding up
   d. An object slowing down

Concept 2: *Acceleration*

Objectives:

Analyze and explain velocity vs. time graphs.

Vocabulary:

Acceleration

Practice:

8. List the different ways an object can accelerate.
9. By the time an airplane reaches the end of a runway, it has reached a speed of 80 m/s in 20 s. What is its acceleration?
10. A puppy is running with a speed of 11.2 m/s towards its owner when it gets distracted by a squirrel and stops running. If it halted its run in 2 s, what was the acceleration of the puppy?
11. Explain what the slopes on a distance vs. time graph and on a velocity vs. time graph tell you.
12. Sketch the following velocity vs. time graphs (you will need 4):
    a. An object not moving
    b. An object moving at a constant speed
    c. An object speeding up
    d. An object slowing down

Concept 3: *Newton's Laws*

Objectives:

Rank objects based on amount of inertia.

Rank objects based on amount of momentum.

Given a scenario, identify and explain which law is at work.

Find net force on an object based on a picture or diagram.

Calculate weight of an object, given its mass.

Vocabulary:

Force
Net force
Inertia
Friction
Air resistance
Law of Universal Gravitation
Weight
Law of Conservation of Momentum

Practice:

13. Explain the difference between balanced and unbalanced forces. Sketch and label values on a picture to support your answer.
14. Differentiate between the factor(s) that affect inertia and momentum.
15. Explain each of Newton's Laws, and give an example of each.
16. Explain the difference between the three types of friction.
17. Sketch and label a picture of a sky diver to explain terminal velocity.
18. A 15.5 kg box is pushed across the lunch table. The acceleration of the box is 24.2 m/s^2. What was the net force applied to the box?
19. Given a force of 56 N and an acceleration of 7 m/s^2, what is the object's mass?
20. If a truck has a mass of 100 kg and a velocity of 35 m/s, what is its momentum?

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Concept 1 Notes: Describing Motion

Questions/Vocabulary

Motion

Reference point

Distance

Displacement

Example #1: *If a soccer player runs after his opponent 50 m north, then turns around and chases him 20 m south, what is his distance and displacement?*

Measuring Motion

Example #2: *A delivery truck drives 4 miles west before turning right and driving 6 miles north to make a delivery. Find the delivery truck's distance and displacement.*

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Speed

Example #3: *Suppose you ran 2 km in 10 min. With what speed did you run?*

Example #4: *Sound travels at 343 m/s through dry air. If a lightning bolt strikes the ground 2 km away from you, how long will it take for the sound to reach you?*

Average speed

Instantaneous speed

Velocity

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Practice Time!

Graphing Motion

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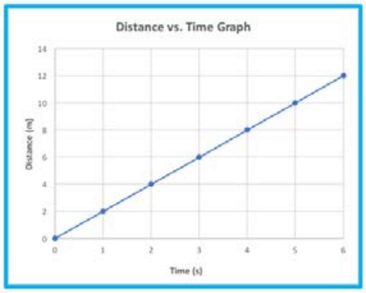

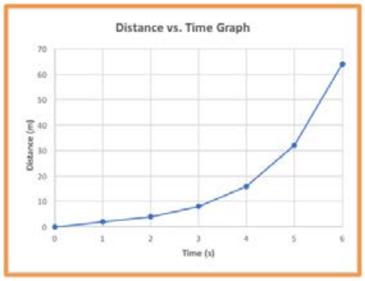

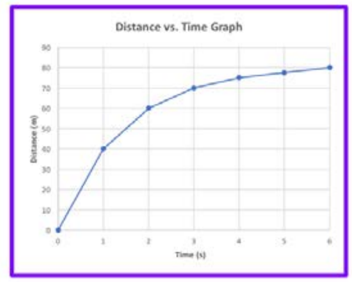

Sketch a graph that would show an object not moving.

Sketch a graph that would show an object moving at a constant speed, stopping, then speeding up.

Summary Concept 1

Summarize the different ways that motion can be described and measured.

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Practice: Distance vs. Displacement

Answer the following questions. Sketch a picture before solving and make sure to show all work. You may need a separate sheet of paper.

1. PJ likes to ride his bike around the block. If he rides out of his house west, the sidewalk circles his block, and brings him back to his doorstep 0.35 miles later. Find his distance and displacement.

2. Nicole parks her car at Target and walks 150 ft north to get to the store. On her way back to her car, she walks 50 ft before pausing when she sees a sign for discounted iced coffee at Starbucks. Find her distance and displacement.

3. Maria is trying to meet her friends at the pool but construction is blocking her path from the parking lot directly to the pool. Because of this, she has to walk 20 ft north, 35 ft east, and then 20 ft south to get to the pool. Find her distance and displacement.

4. Mali loves to make herself dizzy. She spins around in place 7 times before falling down right where she was standing. Find her distance and displacement.

5. Stefan has to drive 8 miles south and 3 miles east to get to work. Find his distance and displacement.

6. Kai swims for the school swim team. He specializes in a backstroke event where he has to swim the 50-m length of the pool three times. Find his distance and displacement.

7. On the way home from school, Taylor's car runs out of gas. He has to walk 25 m north and 10 m west in order to reach the nearest gas station. Find his distance traveled and his displacement from his car.

8. **Challenge**: A delivery truck travels 18 blocks north, 10 blocks east, and 16 blocks south. What is the distance traveled and displacement? Assume all blocks are the same length.

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Practice: Speed and Velocity

Answer the following questions. Make sure to show all work to receive credit. You may need a separate sheet of paper.

1. A student practicing for a cross country meet runs 250 m in 30 s. What is her average speed?

2. What is the velocity of a car that traveled a total of 75 km north in 1.5 hours?

3. A space shuttle orbits Earth at a speed of 21,000 km/hr. How far will it travel in 5 hours?

4. What is the velocity of a plane that traveled 3,000 miles from New York to California in 4.5 hours?

5. A school bus moves at speed of 35 mi/hr for 20 miles. How long will it take the bus to get to school?

6. If it takes 3.5 hours for the Hogwarts Express, moving at a speed of 120 mi/hr, to make it from Platform 9 and ¾ to Hogwarts, how far apart are they?

7. How long would it take for a car to travel 200 km if it has an average speed of 55 km/hr?

8. **Challenge**: A car travels 240 miles south in 3 hours. Find the velocity of the car in mi/hr **and** m/s.

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Activity: Graphing and Analyzing Data

Part 1: *Create four graphs (1 for each data table) for the motion of the objects in data tables 1-4. Make sure to include a title, labeled axes, and a key.*

Data Table 1

Time (s)	Total Distance Traveled (m)
1	3
2	3
3	3
4	3
5	3

Data Table 2

Time (s)	Total Distance Traveled (m)
1	3
2	6
3	9
4	12
5	15

Data Table 3

Time (s)	Total Distance Traveled (m)
0	0
1	5
2	20
3	45
4	80
5	125
6	180

Data Table 4

Time (s)	Total Distance Traveled (m)
0	0
1	50
2	95
3	130
4	155
5	170
6	175

Part 2: *Refer to your graphs and answer the questions below.*

1. Describe the motion of the object in Graph 1.

2. Find the speed of the object in Graph 1.

3. Describe the motion of the object in Graph 2.

4. Find the speed of the object in Graph 2.

5. Explain the difference between the motion of the object in Graph 3 and the motion of the object in Graph 4.

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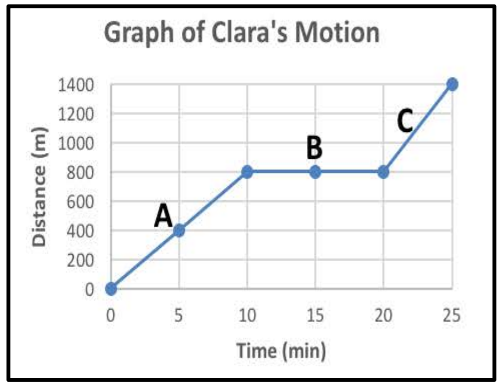
Practice: Motion Graphs

Part 1: *Match the letters on the graph to the statements in #1-3 that best describe Clara's motion. Then answer questions 4 and 5.*



_______ 1. Clara stops for 10 minutes to catch up with a friend.

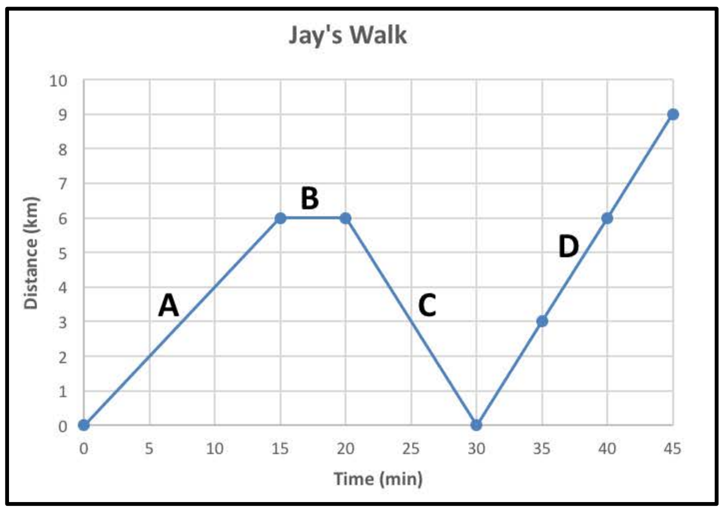
_______ 2. Clara jogs 600 m in 5 minutes.

_______ 3. She walks at a constant speed of 80 m/min.

4. Is Clara jogging faster during part A of her run or part C? Explain how you know.

5. Calculate Clara's average speed for her run.

Part 2: *Use the graph below to answer questions #6-10 about Jay's motion on his walk.*



6. Describe the motion of Jay's walk during part A vs. part C.

7. What is happening at part B?

8. Find Jay's instantaneous speed at 35 minutes.

9. Find Jay's average speed for his walk.

10. Make up a short story to explain Jay's motion during his walk. Make sure to address parts A-D.

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Concept 2 Notes: Acceleration

Questions/Vocabulary

Acceleration

Positive acceleration

Negative acceleration

Example #1: *A car traveling 35 km/hr accelerates to a speed of 45 km/hr in 0.25 hr. What is its acceleration?*

Example #2: *A jet is traveling at 80 m/s when it starts to approach a runway. It is able to land and park in 10 s. What is its acceleration?*

Example #3: *A skateboarder has an acceleration of 1.5 m/s^2. Starting from rest, if he accelerates for 2 s, what speed will he reach?*

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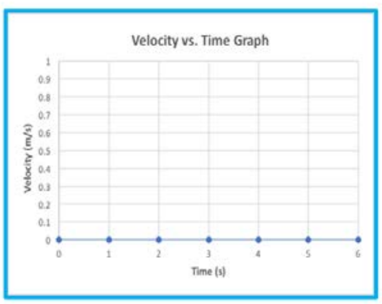
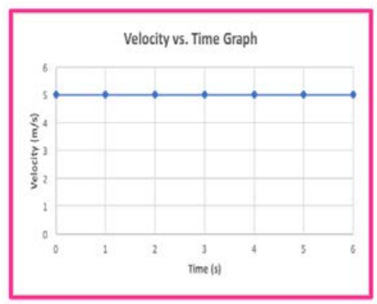
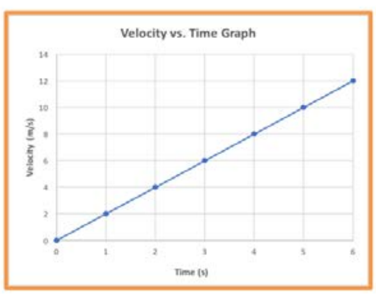
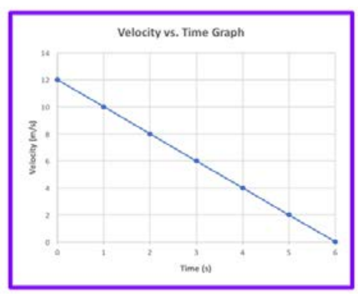
Practice Time!

Graphing acceleration









Summary Concept 2

Explain the different changes in motion that could cause an object to accelerate.

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Practice: Acceleration Math

Answer the following questions. Make sure to show all work to receive credit. You may need a separate sheet of paper.

1. A roller coaster car rapidly picks up speed as it rolls down a slope. As it starts down the slope, its speed is 4 m/s. 3 seconds later, at the bottom of the slope, its speed is 22 m/s. Find its acceleration.

2. A cyclist accelerates from 0 m/s to 8 m/s in 3 seconds. What is his acceleration?

3. A car approaches a stop sign going 5 m/s before it comes to a stop. If it does this in 4 seconds, what was its acceleration?

4. A car advertisement claims that a certain car can accelerate from rest to 70 km/hr in 7 seconds (hint: convert to hours first!!) Find the car's acceleration.

5. **Challenge**: If a Ferrari with an initial velocity of 10 m/s accelerates at a rate of 5 m/s^2 for 3 seconds, what will its final velocity be?

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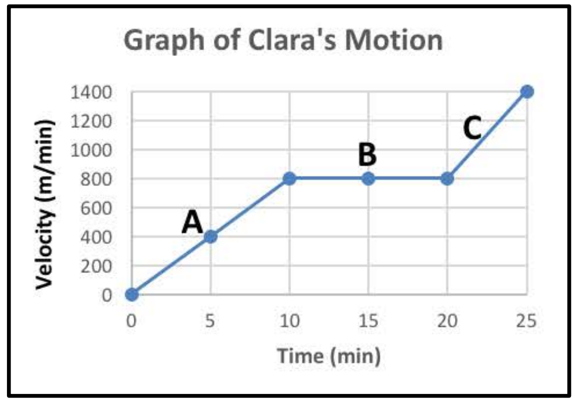
Practice: Acceleration Graphs

Part 1: *Match the letters on the graph to the statements in #1-3 that best describe Clara's motion. Then answer questions 4 and 5.*



_______ 1. Clara has a positive acceleration for 5 minutes.

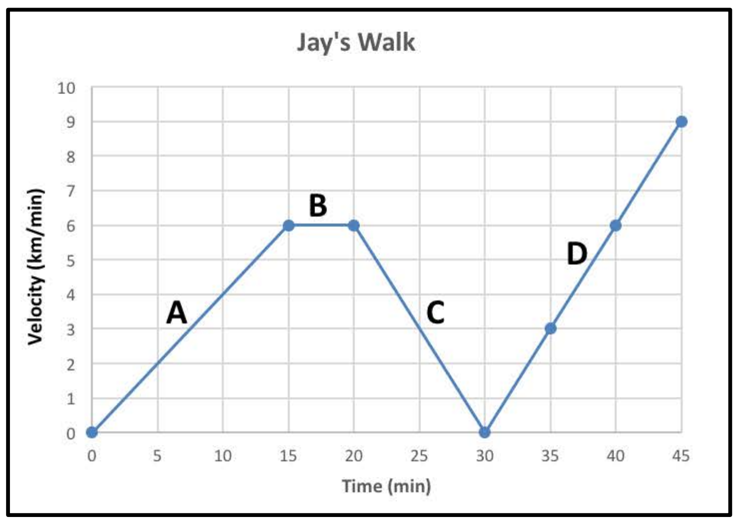
_______ 2. Clara has zero acceleration.

_______ 3. Clara is speeding up for 10 minutes.

4. Calculate Clara's acceleration for part A of her run.

5. Calculate Clara's acceleration for part C of her run.

Part 2: *Use the graph below to answer questions #6-10 about Jay's motion on his walk.*



6. Describe the motion of Jay's walk during part A vs. part C.

7. What is happening at part B?

8. What happens to Jay's motion at 30 minutes into his walk?

9. At what speed is Jay traveling at 5 minutes into his walk? At what time in his walk does he have the greatest speed?

10. Make up a short story to explain how Jay's speed and acceleration changes throughout his walk. Make sure to address parts A-D.

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Lab: Investigating the Velocity and Acceleration of a Runner

Guiding Question: When does a runner reach maximum velocity in a race?

Purpose: To determine at what point in a race a runner achieves their maximum velocity.

Hypothesis: *Make a prediction for when in the race (beginning, middle, or end) a runner will achieve their maximum velocity.*

____

____

____

Materials:

- Stopwatches/timers

Procedure:

1. Determine what roles each group member will have. In every group there needs to be 1 runner and 4 timers. If your group has an extra person, they can be the recorder.
2. Out on the field, the runners for each group will line up on the 0-yard line. The 4 timers in the group should stand at each yard line (10 yd, 20 yd, 30 yd, and 40 yd.) Make sure to line up in a column so that your runner can run in a straight line past each timer.
3. When the whistle blows, all group members will start their timers and the runner will begin running.
4. Each group member will stop his/her timer when the runner passes their mark. At the end of the race, record the times each timer measured in Data Table 1.
5. If any of the group members did not start and stop their timers correctly you must repeat the trial.
6. Each group will complete 3 trials before returning to the classroom to make calculations.
7. Calculate the average times at each distance and record in Data Table 1.
8. Calculate the average velocity at each yard line and record in Data Table 2.

Results

Data Table 1: Running time data

Trial #	Time @ 0 yd (s)	Time @ 10 yd (s)	Time @ 20 yd (s)	Time @ 30 yd (s)	Time @ 40 yd (s)
1	0				
2	0				
3	0				
Average	0				

Data Table 2: Average velocity calculations

Distance (yd)	0	10	20	30	40
Average velocity (yd/s)	0				

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Graphs:

- *Make a **distance vs. time** line graph below using the average times in Data Table 1. You will need to make sure to include a title and labeled X and Y-axis with units.*
- *Make a **velocity vs. time** line graph below using the average velocities in Data Table 2. You will need to make sure to include a title and labeled X and Y-axis with units.*

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Analysis: *Answer the following analysis questions below.*

1. Refer to your distance vs. time graph and explain what it shows you about the runner's motion.

2. Find the line segment in the distance vs. time graph that has the greatest slope. This will tell you when your runner reached their maximum velocity. When was this for your runner?

3. Refer to your velocity vs. time graph and explain what it shows you about the runner's motion.

4. Find the line segment in the velocity vs. time graph with the greatest slope. This will tell you when your runner reached their maximum acceleration. When was this for your runner?

5. Error analysis: Write out three ways your data may not be completely accurate. Think about ways that your numbers collected from each trial may not be consistent with each other. Include a specific solution for each error to prevent these problems in the future for other students who do this lab.

Conclusion

Write a paragraph answering the following questions:
(1) Does the data support your hypothesis or not?
(2) Provide a possible explanation for why the results turned out the way that they did.
(3) Real world application: Consider what you learned in this lab and who this information would be useful for.

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Putting it All Together: Motion

Part 1 Fill in the Blank: *Read the paragraph below that summarizes the content we learned about motion so far. Use Concept 1 and 2 Notes to help you fill in each blank.*

Motion occurs anytime an object changes its 1._______. This is entirely dependent on the 2.__________ point. Motion can be measured by distance, displacement, 3._____________, velocity, and acceleration. Velocity refers to an object's 4._______________ and direction. Acceleration refers to the rate of change in an object's 5.__________ over time. An object can be moving at a constant speed and still accelerating if it is changing 6. _______________. When an object speeds up, it has a 7.______________ acceleration. When an object slows down, it has a 8.______________ acceleration. Motion graphs can be used to help us visualize an object's motion. On a distance vs. time graph, the slope of the line equals the object's 9.__________________, whereas on a velocity vs. time graph, the slope of the line equals the object's 10._________________.

Part 2 Motion Math: *Answer each of the following word problems. Make sure to show all work!*

11. A school bus leaves school and heads east for 2 miles before making its first stop. It then turns left and heads north 3 miles before making another stop. Find the distance and displacement of the school bus after completing its first two stops.

12. A supersonic jet flies 10 miles in 0.008 hours. How fast is the jet moving?

13. An ostrich can run at a speed of 43 mi/hr. How much ground can an ostrich cover if it runs at this speed for 15 minutes? *(Hint: 15 minutes = 0.25 hours)*

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14. A helicopter's speed increases from 25 m/s to 60 m/s in 5 seconds. What is the acceleration of this helicopter?

15. **Challenge**: A cart rolling down an incline for 5.0 seconds has an acceleration of 4.0 m/s^2. If the cart has an initial speed of 2.0 m/s, what is its final speed?

<u>Part 3 Matching</u>: *To the right of the graphs, match each distance vs. time graph in #16-19 with the velocity vs time graph from A-D that shows the same type of motion. Then to the right of the graphs, write a phrase to describe the motion that each graph pair shows. (Ex. Graph #2 matches with Graph Z because both show an object that is…)*

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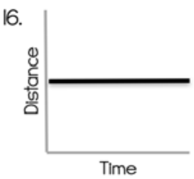

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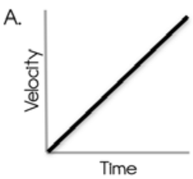

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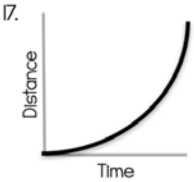

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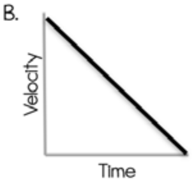

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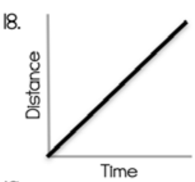

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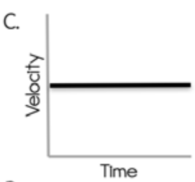

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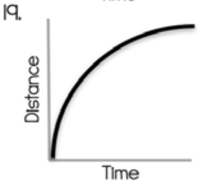

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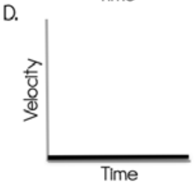
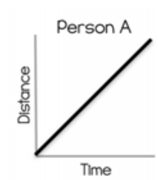
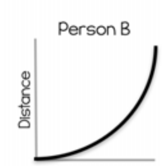


<u>Part 4 Motion Graphing</u>: *Use the Person A and B graphs to the right to answer question 20.*





20. Two different people run a race. The graphs track their distance vs. times during the race. Explain the difference between the two runners' motions. Use words like speed and acceleration in your answer.

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Concept 3 Notes: Newton's Laws of Motion

Questions/Vocabulary

Force

Net Force

Balanced Forces

Unbalanced Forces

Newton's 1^{st} Law of Motion

Inertia

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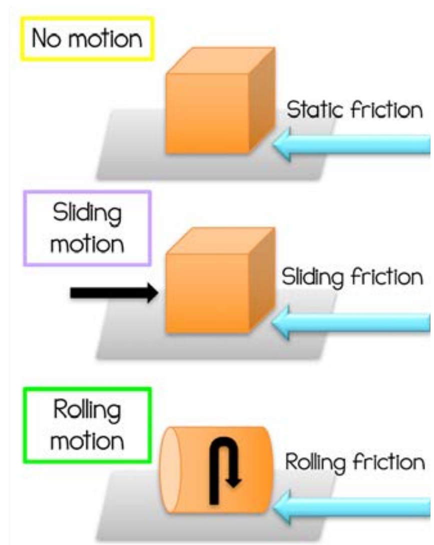
What kinds of forces change an object's motion?

Friction

Depends on 3 factors:

Types of friction:



Air resistance

Determined by:

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Gravity

Law of Universal Gravitation

Depends on:

Terminal velocity

Newton's 2nd Law of Motion

Example #1: *You are pushing a friend on a sled. You push with a force of 40 N. Your friend and the sled together have a mass of 80 kg. Ignoring friction, what is the acceleration of your friend on the sled?*

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Weight

<u>Example #2</u>: *Find the weight of a suitcase that has a mass of 42 kg.*

Weight vs. mass

Newton's 3rd Law of Motion

Momentum

<u>Example #3</u>: *What is the momentum of a car with a mass of 1,300 kg traveling at a speed of 28 m/s?*

Law of Conservation of Momentum

Summary Concept 3

Write a real world example for each of the laws in Concept 3 to help you remember them: Newton's 3 Laws, Universal Law of Gravitation, and Law of Cons. of Momentum.

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Practice: Force and Newton's 1st Law

Answer the following questions. You may use a separate sheet of paper, if needed.

1. Draw and label a picture to show the difference between balanced and unbalanced forces.

2. Explain how balanced and unbalanced forces affect an object's motion differently.

3. Can there be forces acting on an object at rest? Explain why or why not.

4. What is the net force on an object that has balanced forces acting on it?

5. Find the net force acting on the books below.

6. Find the net force acting on the books below.

7. Two students push on a box in the same direction and a third student pushes in the opposite direction. What is the net force on the box if each push with a force of 50 N? (Hint: It may help to draw a picture.)

8. Why is Newton's 1st Law also known as the Law of Inertia?

9. The more __________ an object has, the more inertia it has.

10. Rank the following objects from least amount of inertia to most amount of inertia.

Textbook   Pencil   Kindergartener   Elephant

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Lab Station Activity: Exploring Force and Motion

Answer the questions from each station in the boxes on the next two pages. You do not have to go in order, you just need to make sure you get to every station!

Station 1

Domino Tower

Station 2

Domino Ramp

Station 3

Free Falling

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Station 4

Long Jump

Station 5

Balloon Release

Station 6

Ball Roll

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Practice: Newton's 2nd Law

Answer the following questions. Make sure to show all work to receive credit. You may need a separate sheet of paper.

1. With what force will a car hit a tree if the car has a mass of 3,000 kg and an acceleration of 2 m/s^2?

2. What force would be needed to make a 10 kg bowling ball accelerate down the alleyway with an acceleration of 3 m/s^2?

3. What would be the mass of a truck if it is accelerating at a rate of 5 m/s^2 and hits a parked car with a force of 14,000 N?

4. What is the acceleration of a softball if it has a mass of 0.50 kg and hits the catcher's glove with a force of 25 N?

5. How much does a suitcase weigh if it has a mass of 22.5 kg?

6. What would be the mass of a rock falling from the sky if it hits the ground with a force of 147 N? *(Hint: think about the acceleration all falling objects have!)*

7. Find the acceleration of the stack of books pictured below if the stack has a total mass of 1.5 kg.

8. **Challenge**: A 3 kg model airplane is traveling at a speed of 33 m/s. The operator then increases the speed up to 45 m/s in 2 seconds. How much force did the engine need in order to make this change?

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Project: Newton's Laws of Motion

Background: Sir Isaac Newton lived during the 1600s. Like all scientists, he made observations about the world around him. Some of his observations were about motion. His observations have been supported by more data over time, and we now call these Newton's Laws of Motion. His laws of motion explain rest, constant motion, accelerated motion, and describe how balanced and unbalanced forces act to cause these states of motion.

Newton's 1st Law: ***An object in motion will stay in motion and an object at rest will stay at rest unless acted on by an unbalanced force.***

- An object will not change its motion unless a force acts on it
  - An object that is not moving remains at rest until something pushes or pulls it.
  - An object that is moving remains moving until something pushes or pulls it.
- All objects resist having their motion changed.
  - This tendency to resist a change in motion is called inertia.
  - The more mass an object has, the greater its inertia.

Newton's 2nd Law: The force of an object is equal to its mass times its acceleration.

- A change in motion occurs only if a net force is exerted on an object.
  - A net force changes the velocity of the object, and causes it to accelerate.
  - If a net force acts upon an object, the change in velocity will be in the direction of the net force.
- The acceleration of an object depends on its mass.
  - The more mass an object has or the more inertia it has, the harder it is to accelerate.
  - More mass means less acceleration if the force acting on the object is the same.

Newton's 3rd Law: For every action there is an equal and opposite reaction.

- When one object exerts a force on a second object, the second object exerts an equal force in the opposite direction on the first object.
  - The force exerted by the first object is the action force.
  - The force exerted by the second object is the reaction force.

What to do:

1. Illustrate an example of **each** of the three laws of motion. You may do this by making a:
   a. Poster
   b. PowerPoint
   c. Video
   d. Demonstrations (You must include a written mini lesson plan of what you will do and say for each law for me to grade. You also must provide your own supplies.)
   e. Have a different idea? Run it by me first!
2. Images may be hand drawn, cut from magazines or from the Internet.
3. You must include an explanation ***IN YOUR OWN WORDS*** of how the illustration demonstrates or describes the law of motion. Put the explanation next to the illustration so it is clear which illustration goes with each description.
4. Make sure your project is colorful, neat, and interesting!
5. Use the checklist to make sure you have completed every aspect of the project.

How you will be evaluated:

- This counts as a 100-point test grade
- The rubric on the following page will be used to evaluate your work.

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Newton's Laws of Motion Project Rubric

	Excellent *(20 points)*	**Satisfactory** *(19-16 points)*	**Needs Improvement** *(15-10 points)*	**Unacceptable** *(9-0 points)*
Newton's 1st Law Visual and Description	• All information in the description is accurate. • The illustration accurately represents the law. • No errors in illustration or explanation. • All information is complete.	• All information in the description is accurate. • The illustration accurately represents the law. • No errors in illustration or explanation. • Information is mostly complete.	• Information in the description is partially accurate. • The illustration partially represents the law. • Some errors in illustration or explanation. • Information is somewhat complete.	• Information in the description is inaccurate. • The illustration inaccurately represents the law. • Major errors in illustration or explanation. • Information is incomplete.
Newton's 2nd Law Visual and Description	• All information in the description is accurate. • The illustration accurately represents the law. • No errors in illustration or explanation. • All information is complete.	• All information in the description is accurate. • The illustration accurately represents the law. • No errors in illustration or explanation. • Information is mostly complete.	• Information in the description is partially accurate. • The illustration partially represents the law. • Some errors in illustration or explanation. • Information is somewhat complete.	• Information in the description is inaccurate. • The illustration inaccurately represents the law. • Major errors in illustration or explanation. • Information is incomplete.
Newton's 3rd Law Visual and Description	• All information in the description is accurate. • The illustration accurately represents the law. • No errors in illustration or explanation. • All information is complete.	• All information in the description is accurate. • The illustration accurately represents the law. • No errors in illustration or explanation. • Information is mostly complete.	• Information in the description is partially accurate. • The illustration partially represents the law. • Some errors in illustration or explanation. • Information is somewhat complete.	• Information in the description is inaccurate. • The illustration inaccurately represents the law. • Major errors in illustration or explanation. • Information is incomplete.
Presentation	• Student demonstrates thorough understanding of the content in their presentation. • Time is effectively used. • Information is clear.	• Student demonstrates an understanding of the content in their presentation. • Time is effectively used. • Information is clear.	• Student does not demonstrate complete understanding of all of the content. • Time is somewhat effectively used. • Information is not completely clear.	• Student does not demonstrate a complete understanding of all of the content. • Time is not effectively used. • Information is not clear.
Overall Appearance of Project	• Project demonstrates excellent student effort and time put into its completion. • Project is neat and organized. • Overall project demonstrates creativity and a thorough understanding of the laws.	• Project demonstrates satisfactory student effort and time put into its completion. • Project is neat and organized. • Overall project demonstrates creativity and an understanding of the laws.	• Project demonstrates a lack of student effort and time put into its completion. • Project is somewhat neat and organized. • Overall project somewhat demonstrates creativity and not a full understanding of the laws.	• Project demonstrates unsatisfactory student effort and time put into its completion. • Project is not neat and organized. • Overall project does not demonstrate creativity or an understanding of the laws.

Additional Comments:

Total Points Earned: _______________/100

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Newton's Laws of Motion Project Checklist

Use the list to make sure you have completed every aspect of the project. You may also use the rubric I will be using as a reference too. It's a good idea to practice your presentation as well so you feel comfortable and don't exceed the time limit.

<u>Newton's 1st Law Visual and Description</u>:

☐ Accurate description of Newton's 1st law in own words
☐ Visual/illustration accurately represents the law
☐ There are no errors in the illustration or explanation
☐ The law is completely explained.
☐ Visual and description are clearly labeled with the appropriate law and located together

<u>Newton's 2nd Law Visual and Description</u>:

☐ Accurate description of Newton's 2nd law in own words
☐ Visual/illustration accurately represents the law
☐ There are no errors in the illustration or explanation
☐ The law is completely explained.
☐ Visual and description are clearly labeled with the appropriate law and located together

<u>Newton's 3rd Law Visual and Description</u>:

☐ Accurate description of Newton's 3rd law in own words
☐ Visual/illustration accurately represents the law
☐ There are no errors in the illustration or explanation
☐ The law is completely explained.
☐ Visual and description are clearly labeled with the appropriate law and located together

<u>Presentation</u>:

☐ Can thoroughly explain each law and the connection between the description and the visual you chose
☐ Presentation is no longer than 5 minutes
☐ Presentation of the information is clear so that the class can understand the content and what you are saying
☐ **If using a video,** the camera is stable, sound is clear and understandable, and transitions are smooth.
☐ **If demonstrating for the class**, must provide all supplies needed and demonstrations have clearly been practiced beforehand.
☐ **If using a video or PowerPoint,** make sure it is saved in a format that can be displayed to the class. You may want to come by BEFORE the project is due to make sure it will open and work correctly on my computer. You do not want late points taken off because your project can't be accessed/opened on the day it is due!

<u>Overall Description of Project</u>:

☐ Effort and time put into the completion of the project should be evident
☐ Project is neat
☐ Information is clearly organized
☐ Project demonstrates creativity
☐ Project demonstrates a complete understanding of all of the laws

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Practice: Motion Laws Application

<u>Part 1 Name that Law</u>: *Read each scenario below and name which law is at work. Choose from: Newton's 1st Law, Newton's 2nd Law, Newton's 3rd Law, the Law of Universal Gravitation, and the Law of Conservation of Momentum.*

1. Your dirty clothes, left on the floor overnight, are there when you wake up in the morning
2. Jumping on a trampoline causes you to fly up in the air.
3. A kicked soccer ball will eventually stop rolling, due to the grass.
4. A motorcycle can reach a speed of 60 mi/hr much faster than a minivan can.
5. When a fireman turns on the water coming through the hose he feels the hose push him backwards. Sometimes it takes more than one fireman to hold the hose.
6. A driver isn't paying attention while he texts and drives, colliding with the parked car in front of him and transferring all of his car's moving force into it.
7. You run into your friend while ice skating and both of you fall in opposite directions.
8. The bike you are riding hits a crack in the sidewalk and stops quickly, sending you flying over the handlebars.
9. If you don't keep giving a car gas, the car will eventually stop.
10. A baseball player hits a ball towards the outfield.
11. A satellite in orbit maintains a constant speed while orbiting around the earth.
12. An acorn falls from a tree and lands on the ground.
13. In a head on collision, if you aren't wearing your seatbelt you could go through the window.
14. It takes an airplane nearly ¾ of a mile to stop.
15. Swimming in a pool requires that you push back on the water in order to go forward.

<u>Part 2 Predict the Motion</u>: *Read and predict the motion of the object, based on which law is at work.*

16. According to **Newton's 1st Law of Motion**, if you leave a cookie on a plate and there is no one else in the house, where will the cookie be in an hour?

17. According to **Newton's 2nd Law of Motion**, if you hit a ping-pong pall and a tennis ball with a tennis racket, which one should have a greater acceleration?

18. According to **Newton's 3rd Law of Motion**, if you apply the force of your body down onto a trampoline, what should the trampoline do back to you?

19. According to the **Law of Universal Gravitation**, if you drop a tennis ball and an apple at the same time, what should you observe?

20. According to the **Law of Conservation of Momentum**, if you are playing pool and hit the cue ball at the stationary 8 ball, what should happen?

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Practice: Momentum Math

Answer the following questions. Make sure to show all work to receive credit. You may need a separate sheet of paper.

1. Find the momentum of a 25 kg object traveling at a speed of 4 m/s.

2. A ball has 2 kg*m/s of momentum when thrown with a velocity of 8 m/s outwards. Find the mass of the ball.

3. A 25 kg cart has 125 kg*m/s of momentum. How fast is the car going?

4. A professional baseball player can pitch a baseball with a velocity of 44.7 m/s towards home plate. If a baseball weighs 1.4 N, how much momentum does it have when it hits the catcher's mitt?

5. **<u>Challenge</u>**: In a collision, a 15 kg object moving with a velocity of 3 m/s transfers all of its momentum to a 5 kg object. What would be the velocity of the 5 kg object after the collision? *(Hint: Think about the Law of Conservation of Momentum and draw a picture of what is happening to get started!)*

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Real World Reading: The Physics of Football

Part 1: *Search "Football Physics: The Force Behind Those Big Hits" on Google and click the link to the Forbes.com article. Read the article, in its entirety, and answer the questions below.*

1. Many people make the mistake of believing that when a larger defensive player collides with a wide receiver who is making a catch in the air, the larger defender must be exerting a bigger force on the smaller receiver, leading to a greater chance of injury. This, however, is not true. Explain why and which of Newton's 3 laws supports your answer.

2. What is actually responsible for "the sensation of force" that causes concussions for many professional football players?

3. The only way to protect against the damage from a collision is to reduce the ___________, which is accomplished by wearing what protective football gear?

4. How does the football gear listed in #3 actually help?

5. One of the biggest causes of concussions is collisions with _________________________. Why is this the case?

Part 2: *Search "How do helmets protect football players?" on Google and click the link to the Discover.com article. Read the introduction and watch the short video, then answer the questions below.*

6. What percent of deceased players were found to have suffered from brain disease at the time of their death, according to a 2014 study?

7. Why does your skull not protect your brain as much as you would think?

8. When did it become mandatory to wear hard shell football helmets?

9. How much force do you feel when you are riding in a rollercoaster vs. when two football players crash together at full speed?

10. Explain the difference between the short-term effects of concussions and some of the long-term effects that scientists are recently discovering.

11. The hard shell of the helmet (made from the same material as ________________) helps to prevent ______ _______. But the biggest way helmets help is by spreading out the duration of the _____________. The foam allows for a ________________ of force. The foam padding is the same that you find in _____________.

12. Why is it not helpful to just add more padding to helmets?

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Lab: Balloon Rockets and Newton's Laws

Guiding Question: How will the mass of a rocket affect its acceleration and force?

Purpose: To investigate Newton's 3 Laws of Motion in relation to the movement of a balloon rocket.

Hypothesis: *Make a prediction for how mass will affect the acceleration and force of the balloon rocket.*

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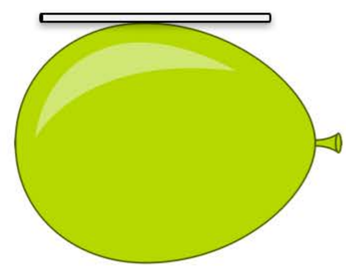
Materials: (per group)

- 1 balloon
- 1 plastic straw
- 2 pencils
- Tape
- Yarn, enough to be tied across the length of the classroom
- Stopwatch/timer
- 2 meter sticks
- Digital scale

Procedure:

1. Determine what roles each group member will have. In every group there needs to be 1 balloon blower-upper, 1 measurer, 1 timer, 1 knot keeper, and 1 recorder. *(If your group has less than 5 people you will need to have multiple jobs.)*
2. Tie each side of the yarn to poles on opposite ends of the classroom.
3. Blow up the balloon so that it has a 5 cm radius. Pinch closed so as not to release any air. Tape the straw to the top of the balloon, as pictured to the right.



4. Let the balloon deflate (the tape will get a little messed up, but that's okay!) and find the mass of your balloon rocket. Record in Data Table 1.
5. Carefully inflate the balloon again to have a 5 cm radius. You may adjust the tape, if needed, but **do not add more tape**. If you do you will have to measure the mass again. Keep the balloon pinched shut so as to not release any air.
6. Untie one end of the yarn. Hold the balloon rocket so that the opening of the balloon faces you. Thread the free end of the yarn through the straw, and retie to the pole. Make sure it is tied tightly so that the yarn is taut. Also make sure that the opening of the balloon (that your hand is holding closed) is in line with the pole and the yarn.
7. Release the balloon and use a stopwatch to record the time it takes for the balloon to stop. It helps if you have a countdown so that the balloon is released and the timer starts at the exact same time. Record in Data Table 1.
8. Use the meter sticks to measure the distance the balloon rocket travels. Record in Data Table 1.
9. Repeat steps 5-8 until you have recorded data in Data Table 1 for 3 successful trials.
10. After the 3rd trial, remove the rocket from the line. Inflate the balloon and tie 2 pencils to the rocket – 1 on either side of the straw. Deflate and find the mass of the new rocket to record in Data Table 2.
11. Repeat steps 5-8 for 3 trials with the new pencil rocket. Record in Data Table 2.
12. Complete all speed, acceleration, and force calculations for each rocket before answering the analysis and conclusion questions.

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Results

Data Table 1: Initial Rocket

Mass =					
Trial	Time (s)	Distance (m)	Speed (m/s)	Acceleration (m/s^2)	Force (N)
1					
2					
3					

Data Table 2: Pencil Rocket

Mass =					
Trial	Time (s)	Distance (m)	Speed (m/s)	Acceleration (m/s^2)	Force (N)
1					
2					
3					

Analysis

Write a paragraph answering the following question. You may need more room on the next page.
(1) Identify the independent variable and dependent variable in this lab.
(2) Refer to your data and explain what it shows you.
(3) Error analysis: Write out at least three ways your data may not be completely accurate. Include a specific solution to prevent each error in the future.

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Conclusion

Write a paragraph answering the following questions:
(1) Does the data support your hypothesis or not? Explain.
(2) Provide a possible explanation, based on what you know about Newton's laws, for why the results turned out the way that they did.
(3) Real world application. Explain how you witnessed each of Newton's 3 Laws of Motion in this lab.

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Putting it All Together: Force

Answer the following questions. Make sure to show all work to receive credit. You may need a separate sheet of paper.

1. What is the net force required to give an automobile with a mass of 1,600 kg an acceleration of 4.5 m/s^2?

2. What is the acceleration of a wagon with a mass of 20 kg if a horizontal force of 64 N is applied to it?

3. What is the mass of an object that is experiencing a net force of 200 N and an acceleration of 500 m/s^2?

4. If a truck has a mass of 2,000 kilograms and a velocity of 35 m/s, what is its momentum?

5. An 8-kilogram bowling ball is rolling in a straight line toward you. If its momentum is 16 kg*m/s, how fast is it traveling?

6. A beach ball is rolling in a straight line toward you at a speed of 0.5 m/s. Its momentum is 0.25 kg*m/s. What is the mass of the beach ball?

7. How much does a 200 kg car weigh?

8. A bicycle takes 8.0 seconds to accelerate at a constant rate from rest to a speed of 4.0 m/s. If the mass of the bicycle and rider together is 85 kg, what is the net force acting on the bicycle? *(Hint: Calculate acceleration!)*

9. Rank the following objects from least inertia to most inertia.
   Baseball   Small car   Truck   Feather   Large train

10. Rank the following objects from least momentum to most momentum.
    Fast car   Parked truck   Slow car   Fast baseball   Fast feather

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