PHYSICS JEDI

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GRADE LEVEL: FIFTH

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Introduction

Physics Jedi is a science based unit written for fifth grade students. This Star Wars themed unit challenges students to master the Force, specifically the many forces of Earth! Students explore how the many forces of Earth are used to create or change the motion of objects. This unit was written using the North Carolina Essential Standards in Science, specifically standard 5.P.1 - Understand force, motion and the relationship between them. This standard contains many sub standards and Physics Jedi focuses on standards 5.P.1.1 - Explain how factors such as gravity, friction, and change in mass affect the motion of objects and 5.P.1.4 - Predict the effect of a given force or change in mass on the motion of an object. This unit also supports the Next Generation Science Standard 5-PS2-1 - support an argument that the gravitational force exerted by Earth on objects is directed down. These standards encourage students to explore how different forces impact the motion of different objects and how the gravitational pull of Earth impacts how objects move.

Physics Jedi is a unit that uses advanced and authentic vocabulary in the sciences. Students practice being practitioners of the physics discipline through exploration and experimentation. Students are challenged to ask and answer high level questions. The Essential Understanding “force stimulates motion” is important for students to understand because objects have a predictable path of motion and those who understand how different forces affect this motion are working towards understanding how to calculate the amount of force needed to move a specific object a specific distance. This skill is laying the foundation for developing skills that will be needed in more advanced science classes in the future.

Differentiation

Physics Jedi is a unit specifically designed for gifted or advanced learners. In lesson one, students may be exposed to the discipline of physics for the first time. Students are asked to work in groups and independently to conduct experiments and answer the question “what does a physicist do?” This Bruner style lesson challenges learners to analyze information, gathered through open ended tasks, and to draw conclusions based on this data. In lesson two, students are challenged to construct models of Land Speeders similar to those seen in the Star Wars franchise. This open ended task requires students to think critically, to compare and contrast the information and technology seen in the movies to what is possible here on Earth. Students have to use or overcome the different forces on Earth in order to successfully meet the challenge of designing a functional Land Speeder. This lesson also introduces students to more advanced science content with the introduction of Newton’s First Laws of Motion - For every action there is an equal and opposite reaction. Lesson three is a visual thinking strategies lesson. VTS lessons challenge students to look closely at images and make observations about what they see. Students practice collaboration and problem solving through respectful communication about what they see in the images. The images students are exploring in this lesson all have examples of forces in them. Students will also make inferences and draw conclusions about forces as they make connections between the science vocabulary and what they see in the images. This open-ended task requires critical thinking, discussion, and debate among students. This lesson builds on lesson two by including the remaining two Laws of Motion. The final lesson in Physics Jedi is a Taba lesson Students are tasked with reading a

challenging text that contains scientific information that is above the current grade level they are in. Students are sorting and resorting ideas from the text about force as they work collaboratively to form generalizations. This task is open-ended and student driven. Students decide how to sort and label the groups and then decide how to resort and reliable the groups. They make inferences and draw conclusions to help them write their own generalization. All of the tasks in this unit require high level thinking and problem solving by the students. They work to solve open ended challenges with multiple answers and multiple routes to those answers. Physics Jedis are asked to think creatively and to challenge themselves to more advanced learning.

Content In this Physics Jedi unit, students work with scientific vocabulary that is advanced and complex. The concept of force extends beyond the knowledge required of fifth grade students. Introducing scientific principles, such as Newton's Laws of Motion, enables students to explain how changes in force impact the motion of an object or multiple objects. Students are also introduced to images that may be new and unfamiliar to them requiring them to transfer knowledge from one format to another. The texts students use in this unit are challenging with a high-level of text complexity.

Process Throughout this unit, students are challenged with tasks that involve advanced levels of critical thinking. Students are asked to infer, make connections, draw conclusions, and develop problem solving skills. Students are required to creatively find solutions to tasks or problems and to be open minded to new and different ideas. These open-ended tasks allow students to dig deeper into a subject and to share their unique perspectives. The collaborative nature of this unit encourages students to challenge

each other and the teacher to engage in high-level, in depth conversation using high level thinking and questioning skills.

Product The products created in this unit will be unique to each student or to each group of students. The open ended nature of the tasks require students to determine how to demonstrate their learning. Students need to think creatively to build their Land Speeder models using recycled materials to represent real-life technology and building materials. Students also have to think creatively and critically to complete the performance task. The performance task is a complex and challenging task that requires students to transfer knowledge from the activities completed in the lessons to a real-world situation.

Learning Environment: Physics Jedi is a student centered science unit. Students often work collaboratively to make sense of new information and to practice new skills. They work to complete open-ended problems or tasks while forming their own ideas about how force stimulates motion. Working in groups encourages the development of leadership and communication skills that will benefit students as they move through life. The hands-on, student driven tasks require a more advanced and complex understanding of the concept then is usually asked for in fifth grade. The tasks the students are performing have many correct outcomes with many different routes to completion. Students may struggle with these tasks because the teacher is not just telling them what to do but is instead allowing and encouraging students to take ownership for their learning and for how they present their knowledge.

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***Content Goals and Objectives*:**

Goal: To develop an understanding of force and motion and the relationship between them.

Students will:

- Know that friction is the result of two or more objects rubbing against each other and be able to explain how an increase or decrease of friction impacts the motion of objects.
- Be able to explain how one can predict the motion of an object based on the force applied
- Understand that a change in mass of an object will change the motion of an object and that this change in motion is predictable
- Describe how gravity affects the motion of objects
- Be able to explain how inertia and momentum affect the motion of objects

Process Goal and Outcomes:

Goal: Conduct experiments and complete activities that explore ways to use forces to change the motion of an object or of objects.

Students will be able to:

- Explain how forces change the motion of objects
- Think critically about the impact different forces have on an object's movement
- Compare and contrast how different forces impact, or change, the motion of an object or objects.

- Work collaboratively to complete activities and experiments that examine the effect of different forces on the motion of objects
- Design and create a model land speeder, making adaptations to the design so that the land speeder will work with or against the forces of Earth
- Problem solve in order to find solutions to challenges regarding forces stimulating change.

Concept Goal and Outcomes

Goal: To understand the concept of FORCE

Students will understand that:

- Force stimulates change
- Using different forces allows people to predict of the motion of an object will change

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Assessment Plan

Throughout the course of the Physics Jedi unit, students will be working on activity and challenges to provide the knowledge that they will use to complete the performance task. The performance task will be introduced on the first day of the unit to provide students with a meaningful purpose for participation and retaining the information.

Performance Task: (The rubric for the performance task can be found at the end of the Assessment Plan section.)

Welcome young Padawans to Jedi Academy of Earth and the start of your training to help the galaxy defeat the Evil Empire! The purpose of your training is to show that you can overcome and/or use Earth's forces to help the Jedi and the Light Side. To show your mastery of Earth's forces, you and your team will be given a scenario to work through and solve. Your team's job is to plan, design and create a device or machine that will help you complete the scenario. Your creation should use the forces of Earth or overcome these forces to help you succeed in your task to defeat the Dark Side. Each Padawan will write a minimum of two paragraphs about their creation. The first paragraph should explain how the device or machine works and how it uses or overcomes the forces of Earth to solve the problem in the scenario. The final paragraph should explain how force stimulates change. Padawans, you will present your creation and your writing to the Jedi Masters of Earth. These Jedi Masters will then decide if you, the young Padawan, are ready to leave Earth and continue your training to defeat the Dark Side and the Evil Empire in a galaxy far, far away

Throughout the unit, students are provided with many opportunities for formative assessment. These formative assessments provide valuable information to the teacher about students current level of understanding and helps teachers identify any misconceptions that students may have. In lesson 1, students work in collaborative groups in a Bruner model lesson to determine what a physicist does and determine why the creator of Star Wars might have a physicist on the production staff. After each rotation, students discuss in their groups what they learned or observed during the rotation. The teacher should be rotating around the room listening to the discussions and making note of student understanding. At the conclusion of all the rotations, there is a whole group discussion based on the activities the students completed. Again, the teacher should be making note of student understanding and identifying any misconceptions students may have so they may be addressed later. At the end of the lesson, students will be using the notes and observations made during the rotations and during the whole class discussion to independently write a two paragraph summary explaining what they think a physicist does and why the creator of Star Wars might use a physicist on the production staff. They will also use words and/or pictures to explain how force stimulates change which is the essential understanding for this unit.

In lesson two, students are working to plan and build a model of a landspeeder for Earth. At the end of day 1, student groups will have created sketches of designs for how they plan on building a landspeeder. As students are collaborating on the planning and designing, the teacher is circulating the room asking clarifying questions, ensuring that all ideas are being heard and that all students are a valued member of the groups. On day 2, students will build their models and present them to the whole class. The final

assessment comes as the groups are explaining how their landspeeders use and/or overcome the forces on Earth to hover and move. After the verbal presentations, the groups will work together, using words and/or pictures, to illustrate the forces that impact the motion of their landspeeders. They will also explain how their landspeeders are an example of Newton's First Law of Motion and answer the essential understanding "how does force stimulate change?"

In lesson three, the Visual Thinking Strategies Model, students present their observations on Star Wars pictures and identify how and where they see forces illustrated in the pictures. This discussion provides the teacher opportunities to gauge the level of comprehension of the topic for individual students and to identify areas where students may need more support. The exit ticket asks students to answer the Essential Understanding "How does Force stimulate change?". This is the third day students have been asked to answer this question. The teacher should be looking for answers that show a deeper understanding or force, motion, and change. Student answers should not be the same as previous days. Students should be showing newly acquired knowledge and a deepening understanding of the concept. Students whose' answers are not showing a growth of understanding may need to be encouraged to think more critically about the question in order to show their deep understanding or students may need more support in developing an understanding of force.

The final lesson of this unit is a Taba lesson. The teacher is assessing student ability to sort and label and then resort and relabel ideas found in a text. After re-sorting and relabeling, students are asking to write generalizations about ideas that are always true about force. These generalizations are shared and recorded so everyone can see.

Students will independently choose the generalization that they feel best answers the essential understanding “how does force stimulate change?” and use examples from the text to support their ideas of why this is the best generalization.

While students are introduced to the performance task on day 1 of the unit, students are not assigned their scenarios until day 3. Students will be assigned a group and given one of the following scenarios to complete the performance task.

- *As you are flying your X-wing with the rebel alliance, you see Storm Troopers below you. Before you can make plans to land, your team of fighters is attacked! You must land safely on the ground so you can clear the area of Storm Troopers. Using your knowledge of Earth’s forces, plan, design, and build a device that will help you, and your damaged ship, avoid a crash landing!*

- *You and the other Padawans are asked to consult with the rebel alliance at Eco Base on the ice planet Hoth. The rebels are having trouble transporting supplies over the icy surface. The tauntauns have trouble keeping the supply sleds in control. Using your knowledge of Earth’s forces, plan, design, and build a machine that can help the Eco Base transport supplies more safely.*

- *Young Padawans of Earth come in! This is Tatuine base! We have been having major wind and sand storms here on Tatuine. Our cruisers are not efficient to use in the strong wind. They get pushed backward or use so much fuel to push their way through the wind! Using your knowledge of Earth’s forces, plan, design, and create a machine that would help us travel during the sand and windstorms.*

On day 3 and day 4, students will work with their team to design and build a machine or device to help the rebels. The rubric for the performance task is below.

Criteria	Above Expectation (4)	Meets Expectation (3)	Near Expectation (2)	Below Expectation (1)
Scenario Situation	Provides an insightful explanation of the problem described in the scenario	Provides a logical explanation of the problem described in the scenario	Provides a simplistic explanation of the problem described in the scenario	Provides a flawed explanation of the problem described in the scenario
Planning and Design	Creates a rich and detailed plan for the design of the machine or device	Creates a specific plan for the design of the machine or device	Creates a simplistic plan for the design of the machine or device	Creates an incomplete plan for the design of the machine or device
Construction of Device or Machine	Constructs an innovative model of a device or machine to solve the problem in the scenario	Constructs an effective model of a device or machine to solve the problem in the scenario	Constructs a workable model of a device or machine to solve the problem in the scenario	Constructs an ineffective model of a device or machine to solve the problem in the scenario
How will model work	Provides a comprehensive explanation of how the model would work in real life	Provides a substantial explanation of how the model would work in real life	Provides a partial explanation of how the model would work in real life	Provides a superficial explanation of how the model would work in real life

Explanation of forces	Writes a comprehensive explanation of how the machine or device uses and/or overcomes the forces on Earth	Writes a specific explanation of how the machine or device uses and/or overcomes the forces on Earth	Writes a partial explanation of how the machine or device uses and/or overcomes the forces on Earth	Writes an undeveloped explanation of how the machine or device uses and/or overcomes the forces on Earth
Essential Understanding: How does force stimulate change?	Provides a perceptive explanation of how force stimulates change with accurate examples	Provides a meaningful explanation of how force stimulates change with accurate examples	Provides a basic explanation of how force stimulates change with accurate examples	Provides a vague explanation of how force stimulates change without examples

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Lesson Plans

TEACHER NAME			Lesson #
Stephanie Sevelovitz			1
MODEL	**CONTENT AREA**	**GRADE LEVEL**	
Bruner	**Science**	**5**	
CONCEPTUAL LENS		**LESSON TOPIC**	
Force		**Force and Motion**	

LEARNING OBJECTIVES *(from State/Local Curriculum)*

5.P.1 Understand force, motion and the relationship between them.
5.P.1.1 Explain how factors such as gravity, friction, and change in mass affect the motion of objects.
5.P.1.3 Predict the effect of a given force or a change in mass on the motion of an object

THE ESSENTIAL UNDERSTANDING *(What is the overarching idea students will understand as a result of this lesson?*	**THE ESSENTIAL QUESTION** *(What question will be asked to lead students to "uncover" the Essential Understanding)*
Force stimulates changes	*How does force stimulate change?*

CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)	**PROCESS SKILLS** (What will students be able to do as a result of this lesson?)
Students will know that: - Friction is a the resistance of one object encounters when moving over another - Gravity is the force by which a planet draws objects toward its center - Mass is the amount of matter an object contains - Balanced and unbalanced forces cause the change in movement of an object - Physicists are a specific type of scientist - Physicist must follow certain rules when they conduct experiments and research - Physicists use specific vocabulary and language of the discipline	Students will be able to: - Make observations - Collect, organize, and analyze data - Make generalizations - Conduct experiments - Make predication - Draw conclusions - Ask questions - Make inferences - Explain thinking - Make connections - Collaborate

GUIDING QUESTIONS *What questions will be asked to support instruction?* *Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding*		
Pre-Lesson Questions:	**During Lesson Questions:**	**Post Lesson Questions:**

- What are some words or phrases that describe a physicist? - What is physics? - What is the relationship between physics and force? - What does a physicist do? What does a physicist study? - How might physicists use force? - What are some tools a physicist could use? - Where do physicist work? - What could we add to our list about what a physicist does after watching the video? - What question could a physicist ask at work? - What characteristics do you think a physicist needs to have? - What ethical issues might a physicist need to think about? - How would knowledge of Newton's First Law of Motion impact space travel? -	- What can you infer from what you experienced? - What predictions can you make or did you make? - What evidence do you have to support your inferences and predictions? - How and where can these forces be observed in the Star Wars universe? - What do you observe throughout these stations? - Why are these observations important? - What inferences did you make based on the activities? - What evidence do you have to support your inferences? - What predications can you make based on any or all of these learning experiences? - How did you use your observations to help you make predictions? - How did you observations affect your inferences? - How are your inferences and predictions alike? - How are your predications and inferences different? - What forces did you observe during these stations? - How are these forces represented in the Star Wars universe? - What examples of friction did you observe? - Where do you see examples of friction in the Star Wars universe? - What examples of change in mass did you observe? - What examples of gravity did you observe? - How does gravity effect the motion of objects in the Star Wars universe? - What are balanced and unbalanced forces?	- What does a physicist do? - How would the creators of Star Wars use a physicist in the production of their films? - What characteristics do you think a physicist needs to have? - What ethical issues might a physicist need to think about? - Where does a physicist work? - What tools would a physicist use? - What does a physicist study? - What does a physicist do? - What are some examples of questions a physicist might ask? - How do physicist use observation to make inferences and predications? - Why might the creators of Star Wars use a physicist on the production crew? - How does force stimulate motion?

	- Where can we see examples of balanced and unbalanced forces in the Star Wars universe? - How is the battle between in the light side and the dark side similar to the battle between balanced and unbalanced forces on Earth? -	

DIFFERENTIATION

(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.

Content	Process	Product	Learning Environment
The vocabulary and concept are technical and sophisticated for this grade level	**The use of Bruner's Structure of the Discipline represents high levels of critical thinking and inferencing. Students work to form their own generalizations about physics, force, and motion.**		**The hands-on and collaborative aspect of this lesson is advanced for this grade level**

PLANNED LEARNING EXPERIENCES *(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)*

Engage and Connect - *This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.*

As students enter the room, they see all of the stations set up around the room. Each station is clearly marked with a number. The materials for each station should be easily seen in order to spark interest and excitement in the students.

**** Prior to beginning this lesson the teacher will introduce the performance task for this unit. Students will not actively work on the performance task until lesson 3. Introducing the performance task prior to lesson 1, provides students with a purpose for staying motivated and engaged in the lessons. The performance task can be found at the end of this lesson. ****

1: Familiarity with the Discipline

The teacher asks:

- What are some words or phrases that describe a physicist?
- What is physics?
- What is the relationship between physics and force?
- What does a physicist do? What does a physicist study?
- How might physicists use force?
- What are some tools a physicist could use?

The teacher adds these answers to the list on the board.

The teacher asks students to watch this video as an introduction to physics. Students will be asked what other ideas about what a physicist does after watching the video.(The narrator of the video has a strong accent. The teacher may wish to turn on subtitles to help students follow along.)
https://www.youtube.com/watch?v=3Mo0sNANQT4
After the video, the teacher will ask:

- What could we add to our list about what a physicist does after watching the video?
- What question could a physicist ask at work?
- What characteristics do you think a physicist needs to have?
- What ethical issues might a physicist need to think about?

The teacher will show this video: https://www.youtube.com/watch?v=ZFOuxAx-dkc&t=228s which discusses some of the troubles with space battles as seen in Star Wars based on our current technology and knowledge of physics. The teacher can ask:

- How would knowledge of Newton's First Law of Motion impact space travel?

Explore - *In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.*

2} Practice the Discipline

The teacher has set up four experiment stations in advance of the lesson. Instructions for the stations and students handouts can be found at the end of this lesson. The stations allow for exploration of the following topics:

- Friction
- Balanced and Unbalanced forces
- Gravity
- Changes in mass

The teacher divides the students into 4 groups. The results of the learning opportunities will work best if there is an even number in each group rather than making each group equal in size. Students are provided with a **Field Notes** document, a pencil, and a clipboard. The teacher provides the following expectations:

- Students will work in pairs at each station to conduct the learning experience.
- The pairs should only communicate with their partner and not with other groups
- Students will work through each of the 4 stations and debrief with the other members of their group as cued by the teacher
- Students must read all directions for the learning experience before beginning
- Students will return all materials neatly when it is time to rotate stations
- Student will write and/or draw what they observed and make predications as needed based on the directions at the station.

Groups will have 10 minutes to complete the learning experience at the station. After 10 minutes, the teacher will cue the groups to gather and discuss what the observed or predicted at the station. Students are encouraged to continue to add ideas and observations to their field notes during this conversation. Students should consider the following questions:

- What can you infer from what you experienced?
- What predictions can you make or did you make?
- What evidence do you have to support your inferences and predictions?
- What forces did you see in action?
- How did these forces affect the motion of the objects?
- How and where can we observe these forces in the Star Wars universe?

After 7 minutes, the teacher will prompt each group to rotate to the next station, find their partner, and begin by reading the station directions.

This process repeats until all students have experienced each of the four stations and debriefings.

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

3} Reflecting on the Discipline

Once the groups have completed all of the rotations, each group is given time to share out their observations, predictions, inferences, and questions. The teacher should record these thoughts on the board or on chart paper, being sure to keep this list separate from the list at the start of the lesson. The teacher may ask the following questions to help keep the conversation flowing:

- What do you observe throughout these stations?
- Why are these observations important?
- What inferences did you make based on the activities?
- What evidence do you have to support your inferences?
- What predications can you make based on any or all of these learning experiences?
- How did you use your observations to help you make predictions?
- How did you observations affect your inferences?
- How are your inferences and predictions alike?
- How are your predications and inferences different?
- What forces did you observe during these stations?
- How are these forces represented in the Star Wars universe?
- What examples of friction did you observe?
- Where do you see examples of friction in the Star Wars universe?
- What examples of change in mass did you observe?

- What examples of gravity did you observe?
- How does gravity effect the motion of objects in the Star Wars universe?
- What are balanced and unbalanced forces?
- Where can we see examples of balanced and unbalanced forces in the Star Wars universe?
- How is the battle between in the light side and the dark side similar to the battle between balanced and unbalanced forces on Earth?

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*

Continued Practice and Reflections

Students will be regrouped into groups of 4. The new groups should contain one member from each of the four original groups. Students will be instructed to work together to answer the question "**What does a physicist do? and "how would the creators of Star Wars use a physicist in the production of their films?"**. These two questions should be posted for the whole class to see and consider as they work in their groups. Each group will be given chart paper for the group to record their ideas on using words and pictures. The chart paper should have the following included:

- What characteristics do you think a physicist needs to have?
- What ethical issues might a physicist need to think about?
- Where does a physicist work?
- What tools would a physicist use?
- What does a physicist study?
- What does a physicist do?
- What are some examples of questions a physicist might ask?
- How do physicist use observation to make inferences and predications?
- Why would an understanding of physics be important to the creator of Star Wars?

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

Each group presents their chart paper to the class. The class may ask clarifying questions after each presentation. Once all groups have shared, the groups are given 5-10 minutes to make any final adjustments to the chart paper adding new information or ideas that they learned during the presentations. To conclude the lesson, each student will write two paragraphs. The first paragraph will explain what they think a physicist does and why the creators of Star Wars might use a physicist on the production crew. In the second paragraph, students will use words and/or pictures to explain how force stimulates motion.

Performance Task

Welcome young Padawans to Jedi Academy of Earth and the start of your training to help the galaxy defeat the Evil Empire! The purpose of your training is to show that you can overcome and/or use Earth's forces to help the Jedi and the Light Side. To show your mastery of Earth's forces, you and your team will be given a scenario to work through and solve. Your team's job is to plan, design and create a device or machine that will help you complete the scenario. Your creation should use the forces of Earth or overcome these forces to help you succeed in your task to defeat the Dark Side. Each Padawan will write a minimum of two paragraphs about their creation. The first paragraph should explain how the device or machine works and how it uses or overcomes the forces of Earth to solve the problem in the scenario. The final paragraph should explain how force stimulates change. Padawans, you will present your creation and your writing to the Jedi Masters of Earth. These Jedi Masters will then decide if you, the young Padawan, are ready to leave Earth and continue your training to defeat the Dark Side and the Evil Empire in a galaxy far, far away

Station Set- Up Directions

Station 1 – Friction

Materials:

- Hot Wheels Cars
- Hot Wheels race track
- Aluminum foil
- Hot glue
- Construction paper
- Rough sand paper
- Stop-watch or other timing device

Set Up:

Decide on the length of track to use for the experiment. Each experiment should use the same length of track and the same drop angle. It is recommended that the top of the track be attached to a chair for consistency. One track is the control, nothing will be done to the surface of the track. Crumple and uncrumple a piece of foil, attach the foil to the track creating a rough surface for the Hot Wheel Cars. On another section of track, create some hot glue squiggles along the length of the track. On a third piece of track attach crumpled up construction paper. On the final piece of track attach the rough sand paper. Mark a finish line on the floor.

Station 2 – Balanced and Unbalanced Forces

https://www.generationgenius.com/wp-content/uploads/2018/03/Balanced-and-Unbalanced-Forces-Lesson-Plan-GG.pdf

Materials:

- 5 – 2 foot long pieces of string or rope

Station 3: Gravity

https://study.com/academy/lesson/gravity-activities-games.html

Materials:

- Apples
- Apples cut in half
- Baseball
- Pens
- Pencils
- Coins
- Golf Ball
- Paper

**May want to cover the floor with newspaper or a tarp in case the apples make a mess

Station 4: Changes in Mass

Materials:

- Hot Wheels Cars
- Hot Wheels track
- 1 inch wooden cubes
- Rubber bands
- Stop watch or other timing device

Set- Up:

Set up the Hot Wheels Track so that each track is the same length. Attach the top of the track to a chair for common starting point. This is the start. Along the floor, mark a finish line. The finish line should be the same distance for each track. Due to time constraints, the teacher should attach 1 and 2 blocks to the roof of some of the cars in advance using the rubber bands. Avoid having the rubber band drag on the track below the car.

Student Field Notes

Station 1:

Work with your partner to time how long it takes the car to get from the start to the finish line.

Steps:

1} Choose a car to use. You will use this car for each of your tests!

Track Used	Time is took to get to the Finish	Observations, thoughts, predictions
Control		
Aluminum Foil		
Construction Paper		
Hot Glue		
Sand Paper		

Station 2:

Tug-of-War

You and your partner are going to play a controlled game of Tug-of-War. It is very important that you follow the directions carefully. Safety is important!

Choose 1 piece of rope. Read each test direction and make a prediction of what will happen ***BEFORE*** performing the task. When you get to the last test, ask the teacher for help.

Directions	Prediction of what happens to each partner	Outcome
Partner A and B pull on the rope with the same amount of force		
Partner A pulls on the rope with more force than Partner B		
Partner B pulls on the rope with more force than Partner A		
With Partner A and B pulling on the rope with the same force the teacher cuts the rope		

Station 3:

Directions: You and your partner are going to performing a series of drop tests. Make your predictions before you drop the items but do not make all of the predictions ahead of time! On partner will pick up the two objects and carefully stand on a chair. Hold the objects out in front of you at the same height. At exactly the same time, you will drop both objects. The second person will watch to see which item hits the floor first.

Items	Prediction	Outcome
Whole apple and half apple		
Baseball and Pen		
Golf ball and coin		
Pencil and sheet of paper		
Create your own combo!		
Create your own combo!		
Create your own combo!		

Station 4

You and your partner will be testing the time it takes for the Hot Wheels car to cross the finish line.

Car	Prediction	Outcome
Car with no block test 1		
Car with no block test 2		
Car with 1 block test 1		
Car with 1 block test 2		
Car with 2 blocks test 1		
Car with 2 blocks test 2		

Field Note Page for Group Discussion

This will be completed after each rotation

Discuss with the entire group what you observed and/or discovered during this activity. Record your thinking below. You can use words and/or pictures to help explain your thinking. You may want to consider the following questions to help you start the conversations.

- What can you infer from what you experienced?
- What predictions can you make or did you make?
- What evidence do you have to support your inferences and predictions?
- What forces did you see in action?
- How did these forces affect the motion of the objects?
- How and where can we observe these forces in the Star Wars universe?

_____ 's observations on station number _____

TEACHER NAME			Lesson #
Stephanie Sevelovitz			2
MODEL	**CONTENT AREA**	**GRADE LEVEL**	
CPS	**Science**	**5**	
CONCEPTUAL LENS		**LESSON TOPIC**	
Force		**Force and Motion**	

LEARNING OBJECTIVES *(from State/Local Curriculum)*

5.P.1 Understand force, motion, and the relationship between them
5.P.1.1 Explain how factors such as gravity, friction, and change in mass affect the motion of objects.

THE ESSENTIAL UNDERSTANDING *(What is the overarching idea students will understand as a result of this lesson?*	**THE ESSENTIAL QUESTION** *(What question will be asked to lead students to "uncover" the Essential Understanding)*
Force Stimulates change	How does force stimulate change?
CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)	**PROCESS SKILLS** (What will students be able to do as a result of this lesson?)
Students will know that: - Gravity affects the motion of an object - Friction affects the motion of an object - Mass affects the motion of an object - For every action there is an equal and opposite reaction (Newton's First Law of Motion)	Students will be able to: Design and create Explain Collaborate Infer Problem Solve Think Critically

GUIDING QUESTIONS
What questions will be asked to support instruction?
Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding

Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:
- What are the differences between how these land speeders travel and the way we travel by car on Earth? - What are the differences between	- Why did you choose the materials you did? - What would these materials represent if we were to build land speeders for real? - What keeps your land speeder aloft?	- How does friction affect the motion of your land speeder? - How does gravity affect the motion of your land speeder?

how these land speeders travel and the way we travel by airplane on Earth? - What are the differences between how these land speeders travel and the way we travel by hover board on Earth? - What forces can you identify in the picture? - What is a prototype? - What is the purpose of a prototype? - How is force illustrated in the pictures? - How is motion illustrated in the pictures? - How does force stimulate motion in the pictures?	- Why did you choose the materials you did? - What would these materials represent if we were to build land speeders for real? - What keeps your land speeder aloft? - What other materials could you have used? - What changes did you make to your design during construction? - What would happen if you changed the mass of your land speeder? - Why were these changes necessary? - What challenges is your group having? - What is your group doing well? - What forces are affecting the motion of your land speeder? - How is you group using forces to stimulate motion?	- How would a change of mass affect the motion of your land speeder? - What forces are used by your land speeder? - What motion will be observed in your land speeder? - How are land speeders an example of Newton's First Law of Motion (For every action there is an equal and opposite reaction)? - How does force stimulate motion?

DIFFERENTIATION *(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.*			
Content	**Process**	**Product**	**Learning Environment**
The content and vocabulary being covered is advanced for this age group	**The CPS model encourages divergent and convergent thinking and develops leadership, teamwork, creativity, and perseverance**	**Student products will vary based on their innovative ideas. The open-ended aspect makes it challenging to all learners**	**Student centered learning experience. Students work in collaborative groups**

PLANNED LEARNING EXPERIENCES *(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)*

Engage and Connect - *This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.*

Students enter the room to find pictures of different Star Wars Landspeeders and hovercrafts hanging around the room. The teacher has on a lab coat and safety glasses. The teacher allows the students to ask about the lab coat and glasses but remains silent to help pique curiosity. There is a table in the back of the room that contains all of the recyclables that students can use for today's activity. The table is covered with a blanket and has a sign that says "No Peeking". Students are given a sticky note and are asked to do a gallery walk around the room visiting each picture. The teacher will que the students to move allowing about 2-3 minutes are each picture. Students will answer the question about the picture on their sticky note and leave the sticky note attached to the wall next to the picture before moving on.

Sample Questions:

- What are the differences between how these land speeders travel and the way we travel by car on Earth?
- What are the differences between how these land speeders travel and the way we travel by airplane on Earth?
- What are the differences between how these land speeders travel and the way we travel by hover board on Earth?
- What forces can you identify in the picture?
- What is a prototype?
- What is the purpose of a prototype?

Students return to their tables and participate in a whole group discussion about the gallery walk. The discussion should focus on the questions above. The teacher should also ask:

- How is force illustrated in the pictures?
- How is motion illustrated in the pictures?
- How does force stimulate motion in the pictures?

The teacher will show a minimum of 1 of the following videos to show Star Wars Cruisers in action. Each video shows a different type of cruiser.

https://www.youtube.com/watch?v=2P4Q50PiGCo – Star Wars: A New Hope
https://www.youtube.com/watch?v=uAjS-oyNjrg – Star Wars: Return of the Jedi
https://www.youtube.com/watch?v=sDoSxywBT88 – Star Wars: The Force Awakens (the first 10 seconds of the video of the best)

The teacher may also choose to show the video below that connects the technology seen in Star Wars needed for space travel to technology and forces on Earth.

https://www.youtube.com/watch?v=fFZaxoAwhEc&list=PL148kCvXk8pB-kKjH-oxJa9AGBCeiCl27&index=6

The teacher will reveal the contents of the back table.

Explore - *In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.*

Workshopping the lesson will take place over 2 days. Day 1 goal is to have a completed sketch of the land speeder. On day 2, students will construct their landspeeder and present it to the class explaining their design process and how they used or overcame forces to make the landspeeder hover. It is marked in the lesson where day 2 begins.

Mess Finding: Day 1

The teacher will provide students with the following challenge. " Young Padawans, this galaxy has yet to create and utilize hover crafts and land speeders as a means of travel. Using the materials on the table (a collection of recycled materials such as popsicle sticks, toilet paper tubes, cardboard, water bottles, etc…) you and your group will build a prototype land speeder for Earth.

Fact Finding:

Students can view the items but cannot touch them at this time. They will begin to gather data and facts necessary to solve the challenge presents. Students are reminded of the Jedi Rules of Engagement:

- Jedi's respect the ideas of all group members
- Jedi's are respectful of the materials provided
- Jedi's have an open mind to new and different ideas
- Jedi's work best as a team

The teacher goes over the rules and procedures with all students. It is expected that all students work in groups and everyone participates.

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

Problem Finding:

Students will begin to work on identifying different ways to make their vehicle hover. Working as a team, they will determine their objective and what they aim to accomplish.

Idea Finding:

Teams will be given 20 -30 minutes to sketch their designs. They will not begin construction until the explain phase of the lesson. The designs should be creative and be able to be built out of the materials provided. Students will need to discuss what the different recyclable materials represent and how those materials will allow the land speeder to hover. Students will begin by

brainstorming all ideas and possibilities. The teacher will circulate around the room, acting as a facilitator.

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connection*
ns to other related concepts, and apply their understandings to the world around them in new ways

Solution Finding:
Students use convergent thinking to narrow down and decide on the best prototype design. All ideas of evaluated and the best idea or a combination of ideas are selected for building the prototype.

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

Acceptance Finding: Day 2
Students develop a plan for building their prototypes. Each team member is assigned a role:

- Jedi Record Keeper (Note Taker)
- Time Keeper
- Materials Manager
- Jedi High Council (Peace Keeper)

Groups are given 30 minutes to construct their land speeders. The teacher may adjust the time as needed. The materials manager is the only person in the group allowed to go to the materials table for supplies. The teacher circulates the room asking questions and ensuring participation from all students.
Questions to ask:

- Why did you choose the materials you did?
- What would these materials represent if we were to build land speeders for real?
- What keeps your land speeder aloft?
- What other materials could you have used?
- What changes did you make to your design during construction?
- What would happen if you changed the mass of your land speeder?
- Why were these changes necessary?
- What challenges is your group having?
- What is your group doing well?
- What forces are affecting the motion of your land speeder?
- How is you group using forces to stimulate motion?

After building time is complete, each group will display their land speeders and describe how their land speeder moves and hovers. Groups are also asked to identify the forces that impact the movement of their land speeders and to explain how they use those forces or overcome those forces to design their land speeder.

After all groups present, the groups will work together to draw a final copy of what their prototype looked like. The groups will use words and/or pictures to illustrate the forces that affects the motion of their land speeder. If groups are struggling the teacher may ask:

- How does friction affect the motion of your land speeder?
- How does gravity affect the motion of your land speeder?
- How would a change of mass affect the motion of your land speeder?
- What forces are used by your land speeder?
- What motion will be observed in your land speeder?

All groups will explain how their land speeder hovers. Each group will also answer the following questions:

- How are land speeders an example of Newton's First Law of Motion (For every action there is an equal and opposite reaction)?
- How does force stimulate motion?

Gallery Walk Pictures:

https://starwars.fandom.com/wiki/Landspeeder

https://www.starwars.com/databank/reys-speeder

https://www.pinterest.co.uk/pin/803822233471848750/

https://www.pinterest.com/pin/561190803566329594/

TEACHER NAME			Lesson #
Stephanie Sevelovitz			3
MODEL	**CONTENT AREA**	**GRADE LEVEL**	
Visual Thinking Strategy	**Science**	**5th**	
CONCEPTUAL LENS		**LESSON TOPIC**	
Force		**Force and Motion**	

LEARNING OBJECTIVES *(from State/Local Curriculum)*

5.P.1 - Understand force, motion and the relationship between them

5.P.1.1 - Explain how factors such as gravity, friction, and change in mass affect the motion of objects.

5.SL.5.1 – Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly

THE ESSENTIAL UNDERSTANDING *(What is the overarching idea students will understand as a result of this lesson?*	**THE ESSENTIAL QUESTION** *(What question will be asked to lead students to "uncover" the Essential Understanding)*
Force stimulates change	*How does force stimulate change?*
CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)	**PROCESS SKILLS** (What will students be able to do as a result of this lesson?)

Students will know : - That a force is a push or a pull on an object - Motion is affected by the different forces on Earth - Gravity, friction, and change in mass are forces that affect the motion of objects - Newton's First Law of Motion is the law of inertia. Objects at rest tend to stay at rest, and an object in motion tends to stay in motion, with the same direction and speed. - Newton's Second Law of Motion states that force=mass x acceleration which means the more force = more acceleration - Newton's Third Law of Motion states that for every action there is an equal and opposite reaction http://www.physics4kids.com/files/motion_laws.html	Students will be able to: - Analyze - Explain - Infer - Communicate - Observe - Discuss and debate

GUIDING QUESTIONS ***What questions will be asked to support instruction?*** ***Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding***		
Pre-Lesson Questions:	**During Lesson Questions:**	**Post Lesson Questions:**

- What does force mean? - What is motion? - What are some examples of force or forces? - How does force affect motion? - What is change? - How does an athlete use force in their sport? **Questions for engage activity:** - What do you see? - What do you hear? - What do you smell? - What do you wear while doing this activity? - What are your arms doing? - What are your legs doing? - What is your body doing? - What equipment besides your body are you using? - What does that equipment do? -	- What do you see in this picture? - What are the people doing? - What else do you see? - What do you think is happening in this picture? - What do you see that makes you say that? - What are the people doing? - Why did you say that? - What example of forces do we see in the picture? - What do you see that makes you think that these are examples of forces? - How do these forces affect the motion of the people? - Why makes you say that? - How does this picture represent force? - What forces do you see represented in the image? - Why do you say this? - Where do you see friction in this picture? - What makes you say that? - Why do you say that?	- What do you see? - What do you see that makes you say that? - What else do you see? - What do you see that represents force in your picture? - Which of Newton's Laws are depicted in the image? - What do you see that makes you say that? - How is gravity shown in the image? - What evidence from the picture can you use to defend your answer? - How is inertia depicted in the image? - What do you see that makes you say that? - What evidence of momentum do you see in the image? - What did you see that made you say that? - How is inertia depicted in the image? - What did you see that made you say this? - How does force stimulate change?

DIFFERENTIATION

(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.

Content	Process	Product	Learning Environment

The artwork/pictures used in this lesson is unfamiliar to student. It may illustrate concepts which are not a part of the curriculum of this grade level	**VTS is an open- ended thinking strategy which allows and encourages students to share their unique perspectives and make inferences.**		**This is a student led learning activity**

PLANNED LEARNING EXPERIENCES *(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)*

Engage and Connect - *This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.*

**** Prior to beginning this lesson, students are put into learning teams of three and assigned the scenario they will need in order to complete the performance task. Students will begin working on the performance task at the end of this days lesson. The scenarios can be found at the end of this unit****

As students enter the room, the Rey and Kylo Ren battle in the red throne room picture will be projected on the board or copies will be provided for students if working in a room with no projector.
The teacher will ask the pre-lesson questions:

- What does force mean?
- What is motion?
- What are some examples of force or forces?
- How does force affect motion?
- What is change?
- How does an athlete use force in their sport?

Students will be asked to imagine themselves playing their favorite sport or playing a game in PE. Students will be asked to close their eyes and think about the following questions:

- What do you see?
- What do you hear?
- What do you smell?
- What do you wear while doing this activity?
- What are your arms doing?
- What are your legs doing?
- What is your body doing?
- What equipment besides your body are you using?
- What does that equipment do?

Students will share with table groups what they were imagining and share some of their answers to the questions asked using as much detail as possible.

Explore - *In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.*

The teacher will direct students' attention to the pole-vaulting picture displayed on the board or available on student desks. Students are directed to study to picture independently and silently for 2-3 minutes. After 2-3 minutes the teacher will go through several rounds of asking several individual students:
1} What do you see?
2} What makes you say that?
3} What else do you see?
4} What makes you say that?

Every student that volunteers to share will be given the opportunity to answer both of these questions. The teacher may summarize or rephrase student responses. The teacher will go no opinions or pass no judgement about what the student says but may point to the area of the picture to which the student refers.

As the conversation about initial observations continues, the teacher will ask the following questions to get the students to look more closely at the picture:

- What else do you see?
- What do you see that represents force?

- What did you see that made you say that?

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

After students are given the chance to observe and study and discuss the pole-vault picture, the teacher and students look at how forces are illustrated in the picture.

- How is gravity shown in the image?
- What do you see that makes you say this?
- What evidence of inertia can you identify in the picture?
- What made you say this?
- Where do you see friction in this picture?
- What makes you say that?
- How is inertia depicted in the image?
- Why do you say that?
- How does this picture represent force?
- What made you say this?
- How does force stimulate change?

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*

Students will work in groups of 2-3 for this portion of the lesson. Student groups will be assigned randomly. The teacher will hand out pictures and students will find the people who have the same picture as them to work with.
Students will analyze the pictures using the VTS strategies learned earlier in class. The teacher will circulate and help prompt students to ask:

- What do you see in this picture?
- What are the people doing?
- What else do you see?
- What do you think is happening in this picture?
- What do you see that makes you say that?
- What are the people doing?
- What forces can you identify in the picture?
- What makes you say that?
- Which of Newton's Laws are evident in this picture?
- Why do you say this?

Each group will come up with answers to the following questions to share with the class:

- **What are the people in the picture doing?**
- **What forces are seen in this picture?**
- **How are these forces illustrated?**

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

Student groups will present their pictures and their answers to the above questions to the class. After each presentation, other groups can ask clarifying question or build on the information shared by the group presenting.

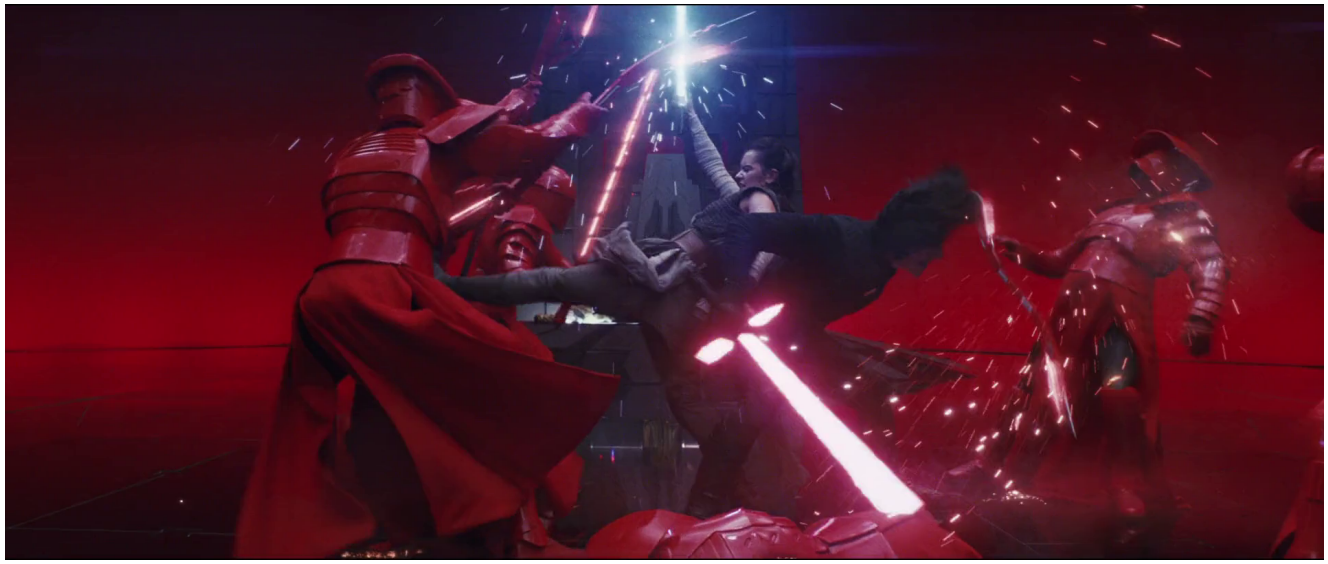
After all presentations, students will be given the question: How does force stimulate change? and be asked to complete an exit ticket. Each student will provide their own answer to this question using the knowledge they gained from examining the pictures.

Performance Task Scenarios

- *As you are flying your X-wing with the rebel alliance, you see Storm Troopers below you. Before you can make plans to land, your team of fighters is attacked! You must land safely on the ground so you can clear the area of Storm Troopers. Using your knowledge of Earth's forces, plan, design, and build a device that will help you, and your damaged ship, avoid a crash landing!*

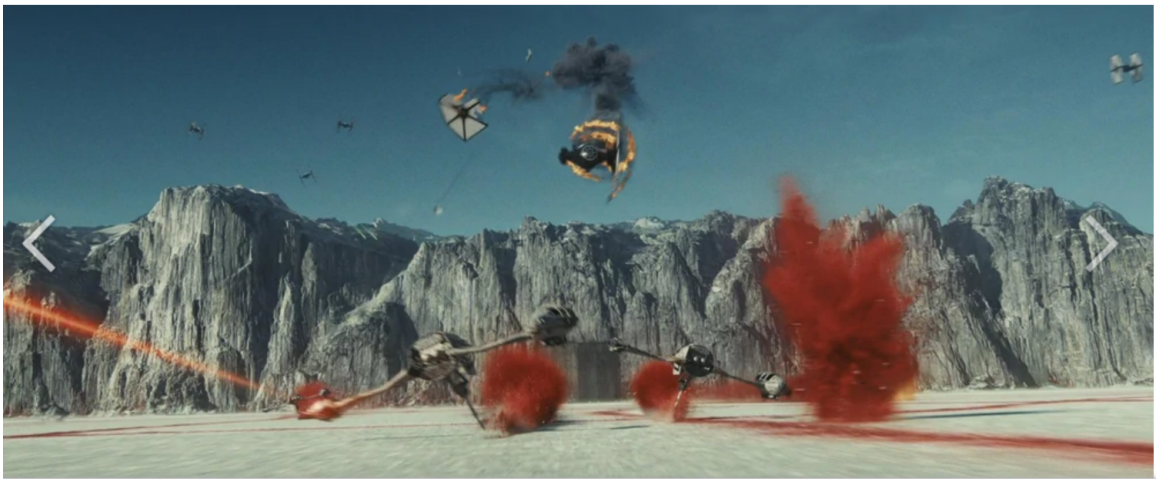
- *You and the other Padawans are asked to consult with the rebel alliance at Eco Base on the ice planet Hoth. The rebels are having trouble transporting supplies over the icy surface. The tauntauns have trouble keeping the supply sleds in control. Using your knowledge of Earth's forces, plan, design, and build a machine that can help the Eco Base transport supplies more safely.*

- *Young Padawans of Earth come in! This is Tatuine base! We have been having major wind and sand storms here on Tatuine. Our cruisers are not efficient to use in the strong wind. They get pushed backward or use so much fuel to push their way through the wind! Using your knowledge of Earth's forces, plan, design, and create a machine that would help us travel during the sand and windstorms.*



https://imgur.com/r/StarWars/j8EAF

https://www.starwars.com/endor-history-gallery



https://starwars.fandom.com/wiki/Battle_of_Crait?file=Battle_of_Crait.jpg

This is a more challenging picture than the rest.

https://thecomeback.com/pop-culture/star-wars-the-force-awakens-begins-the-search-for-reys-family-tree.html

TEACHER NAME		Lesson #
Sevelovitz		4
MODEL	**CONTENT AREA**	**GRADE LEVEL**
Taba	**Science**	**5th**

CONCEPTUAL LENS	LESSON TOPIC
Force	**Force and Motion**

LEARNING OBJECTIVES *(from State/Local Curriculum)*

5.P.1 - Understand force, motion and the relationship between them
5.P.1.1 - Explain how factors such as gravity, friction, and change in mass affect the motion of objects.
5.SL.5.1 – Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly

THE ESSENTIAL UNDERSTANDING *(What is the overarching idea students will understand as a result of this lesson?*	THE ESSENTIAL QUESTION *(What question will be asked to lead students to "uncover" the Essential Understanding)*
Force stimulates change	*How does force stimulate change?*

CONTENT KNOWLEDGE *Force stimulates change* (What factual information will students learn in this lesson?)	PROCESS SKILLS (What will students be able to do as a result of this lesson?)
Students will know : - That a force is a push or a pull on an object - Motion is affected by the different forces on Earth - Gravity, friction, and change in mass are forces that affect the motion of objects - Newton's Laws of Motion allows people to predict how an object moves and where it will move to - Velocity is the speed of an object in a given direction - Acceleration is the rate of change in an objects velocity per unit of time	Students will be able to: - Analyze - Work collaboratively - Compare and contrast - Summarize - Discuss and debate - Draw conclusions - Create generalizations - Categorize - Subsume - Label

GUIDING QUESTIONS

What questions will be asked to support instruction?

Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding

Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:
- What is force? - What are some examples of forces? - What is motion? - What is velocity? - What is acceleration? - Where during the battle did you see examples of forces? - Where did you see evidence of changes in motion? - What forces did you see Luke or Darth Vader use to change their own motion or the motion of each other?	- How did you group these words/ phrases? - Why did you group them the way that you did? - What labels could you use to help explain your groups? - Why did you choose the labels you did? - Which groups could you subsume into another group? - How else could you regroup these words/phrases? - What generalization could you make after reading the article that demonstrates the relationship between force and change in motion? -	- What are some examples of force in the article? - How do these forces affect the motion of the people or other objects in space? - How did Leia use forces to get back on the ship? - What is the relationship between force and motion? - How did different forces affect the motion of an object or person in the article you read? - What generalization can you make about "force" that is always true? - How does force stimulate change?

DIFFERENTIATION *(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.*			
Content	**Process**	**Product**	**Learning Environment**
This lesson contains above level reading and vocabulary. The content being taught is usually taught in higher grade levels.	**Students work in collaborative groups and engage in in-depth thinking. Concepts are developed using critical thinking and generalizing.**		**Small group and whole group discussion. Student led movement through the different phases of Taba.**

PLANNED LEARNING EXPERIENCES *(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)*

Engage and Connect - *This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.*

To begin the lesson, the teacher will ask students to activate prior knowledge by asking:

- What is force?
- What are some examples of forces?
- What is motion?
- What is velocity?
- What is acceleration?

The teacher will then show the video of the battle between Luke Skywalker and Darth Vader from Star Wars: A New Hope

https://www.youtube.com/watch?v=U1MnMA0TzGI&t=9s

- Where during the battle did you see examples of forces?
- Where did you see evidence of changes in motion?
- What forces did you see Luke or Darth Vader use to change their own motion or the motion of each other?

Explore - *In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.*

1} Listing: The teacher will create groups for students to work in during this activity. The teacher should show this clip to remind students what scene in Star Wars The Last Jedi:
https://www.youtube.com/watch?v=6WzSdfKS1w4
Students will read the article: Those scenes you hated in 'Star Wars: The Last Jedi' made total sense by: Robert Lea. The article is linked here but you can also access it below.
https://medium.com/@roblea_63049/those-scenes-you-hated-in-star-wars-the-last-jedi-made-total-sense-733750b1ba20
As they read, students are expected to underline or highlight words or phrases that are related to some aspect of "force". **This is a long article. Modifications can be made to only use the section on Leia using the Force to get back aboard the ship.**

Once students have finished, they will share the words and/or phrases they identified orally and the teacher will create a full list on the board. The teacher may ask students: how does this word or phrase relate to some aspect of "force"?

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

2} Grouping and Labeling: Working in the teacher chosen groups, students will select 20 words/phrases from the complete list on the board and copy them onto sticky-notes or index cards. The students will work together to create groupings of these words/phrases based on similarities. The teacher may ask: " Which of the words/phrases should be grouped together as they relate to "force"?

Expectations:

- There must be a minimum of 4 different groups
- Each group must have a minimum of 3 words or phrases
- No word can be a member of more than one group. If you feel a word belongs in more than one group choose the one that fits it best

The teacher will circulate through the room checking on students groups and listening to group conversations. The teacher will guide students as necessary with questions but each group must come to their own conclusions.

When students finish putting the words/phrases into groups, the teacher will ask students to create labels for the group that indicate how the words/phrases are connected. Students will explain their reasons to the teacher and whole class. The teacher will ask students to defend how they grouped the words and what labels they choose.

The teacher will ask:

- How did you group these words/ phrases?
- Why did you group them the way that you did?
- What labels could you use to help explain your groups?
- Why did you choose the labels you did?
- Which groups could you subsume into another group?
- How else could you regroup these words/phrases?
- What generalization could you make after reading the article that demonstrates the relationship between force and change in motion?

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*

3} Subsuming, Regrouping, Renaming

Students will now be asked to regroup their words into new groups. Subsuming (one group merges with another group). These new groups must have new labels.

Expectations:

- Words/phrases can be used in more than one group (be sure to provide additional sticky-notes or index cards as needed)
- New labels must be assigned to the groups
- All groups must have a minimum of 3 words/phrases

The teacher will ask groups to share their new groupings and the new labels. Groups will have to defend the choices they make about these new groups.

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

4} Generalizing

Each group will work together write a statement, based on what you have learned from this lesson that is always true about "force." Each group will share their generalizations to the whole class and defend the generalization that their group wrote. The teacher will record all of the generalizations on the board.

The teacher will ask:

- What are some examples of force in the article?
- How do these forces affect the motion of the people or other objects in space?
- How did Leia use forces to get back on the ship?
- What is the relationship between force and motion?
- How did different forces affect the motion of an object or person in the article you read?
- How does force stimulate change?

Working individually, students will choose one of the generalizations on the board that they feel is the best answer to "how does force stimulate change?" They will write a paragraph explaining why that generalization is best using evidence from the article to support their ideas.

Those scenes you hated in 'Star Wars: The Last Jedi' made total sense

Robert Lea Follow
Sep 9, 2018 · 12 min read ★

Last year saw the release of the most divisive entry into the *Star Wars* franchise thus far. Much of the scorn poured on the film by fans centred on two early scenes which critics insist lack 'scientific credibility'. But are these moments actually as implausible as it may seem?

Let's look at two scenes which seem to have drawn the most ire. Firstly Leia's 'Mary Poppins' float back into a ship she's just been blown out of. Secondly, the act of the rebels 'dropping bombs' in space.

Before I start this post it's important that I make two disclaimers. Firstly, this is no way a defence of 'the Last Jedi'. Truth is I haven't seen it. Rather I aim to address the critics who have attempted to poke holes in the 'science' of the film.

Secondly, the main criticism I have of the people who attempt to highlight errors in the scientific accuracy of '*The Last Jedi*' is that this is a film about space wizards aimed at children. Why are you even attempting to poke holes in its science?

It's about magic!

With that said, if you are going to attack a film on the basis of scientific accuracy, you could at least ensure that you are being scientifically accurate!

I'm aware I'm nitpicking, but I think nitpicking in response to nitpicking is totally valid.

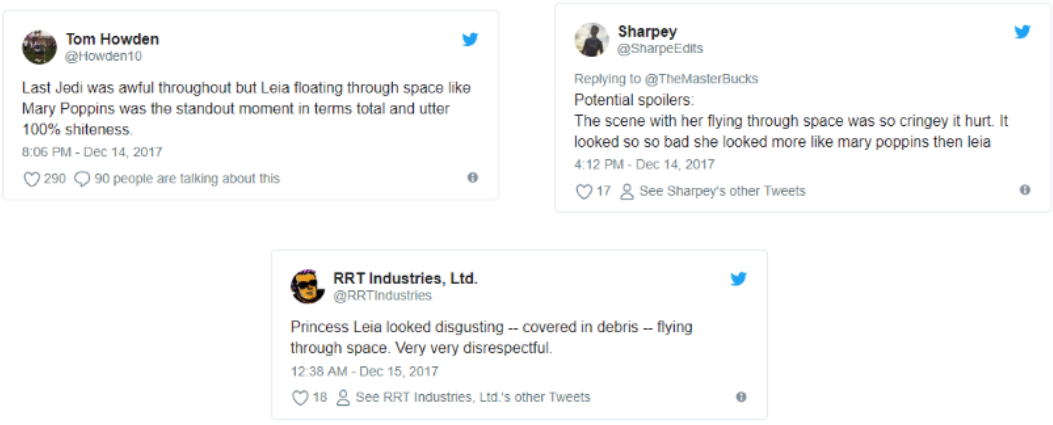
Use the Force... and Newton's first and third laws of motion.

Without a doubt, the scene in the Last Jedi that has caused the most mockery and ridicule is the section in which Leia is blown from her ship and seen floating in space.

She opens her eyes reaches out her hand and... pulls herself back into the ship.

No. Leia isn't 'flying' in this scene

Fans were appalled. "The force has never been shown to allow people to fly!" they screamed.



This may well be true, I don't know enough about Star Wars to say whether its mythical force allows flight. What I can say is that what Leia does in this scene is entirely consistent with what I've seen in Star Wars movies before.

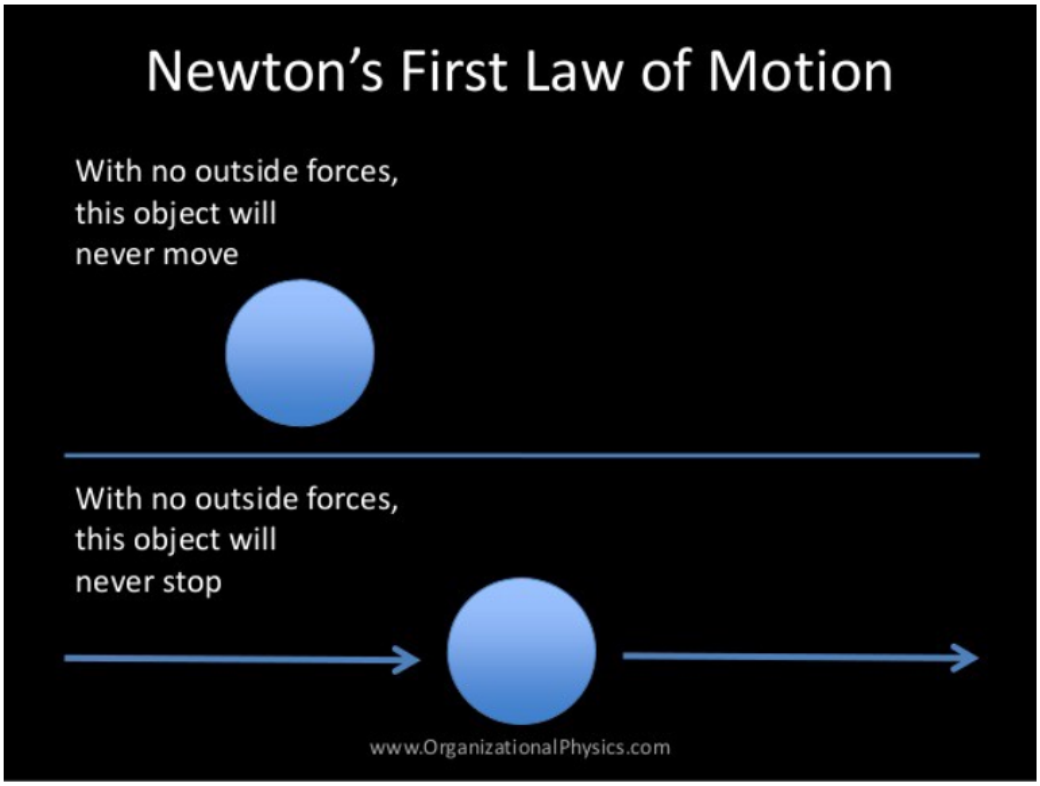
In fact, what Leia does in this scene is absolutely no different from what Luke does in the opening moments of *'The Empire Strikes Back'*. Or what Rey does at the climax of *'The Force Awakens'*. The moments in which they pull their lightsabres towards their hands.

That's all Leia is doing.

Sceptical?

Good. Let's use Newton's laws to explain.

Newton's first law tells us that objects in motion remain in motion unless acted upon by a force (no not the Force). That may seem like it makes total sense, but that's until we consider what would happen to an object put in motion that had no forces acting upon it.



It would just keep moving at the same velocity and in the same direction.

Obviously, when we consider Newton's first law on Earth there is pretty much always a force resisting motion. Whether that's drag from the atmosphere of friction from a surface. On Earth, an object put in motion will eventually come to a halt.

In space, the time it takes for an object to come to rest would be significantly longer. In a particularly empty area of space, it may never come to a halt.

So Leia isn't 'flying' or even floating really. All she really needs to do is apply a small amount of force to propel her in the right direction. She'll keep going until a force acts on her causing her to come to halt.

But how does she get that initial 'kick' in the right direction?

Pull you. Push me. Using Newton's third law.

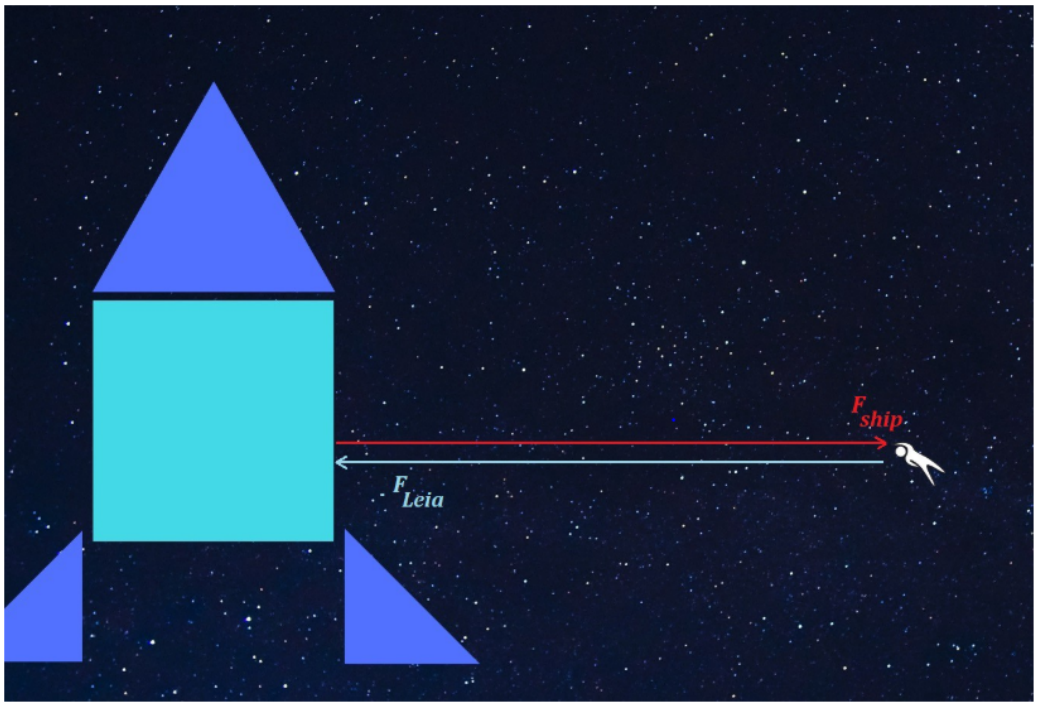
As I said above, what Leia actually does isn't that different than the 'force pull' trick used by Luke and Rey earlier in the series (and probably many more characters too, please don't send me examples of Kit Fisto using the force pull). It may seem different because in those scenes our Jedi don't shoot towards their weapons.

There's a couple of reasons for this. Firstly the weapons are clearly much lighter than our heroes. Secondly, they are performing the trick on a planet with an atmosphere with the effects of gravity in full force.

In the 'Mary Poppins' scene, Leia may well be using the fact that Newton's third law states that for every action there is an equal an opposite reaction. So when your feet press on the floor as you walk, the floor pushes back on your feet.

In the scene, Leia may be *'force pulling'* an object in the ship or the ship itself. Thus, any pull that Leia exerts on the ship will result in the ship pulling back on Leia with equal force.

The two form what is referred to as a *third law pair*.



As Leia pulls on the ship, an equal and opposite force pulls her towards the ship. Obviously, the considerable difference in mass between Leia and the ship works in the Princesses favour here.

Thus, whilst the scene may look silly, it's actually quite consistent with Newton's laws of motion.

The 'Bomber' scene. There's no gravity in space! Right?

During the course of the film, the Rebels lead a daring bombing-raid is space. The criticism being, how can one 'drop' a bomb in space when there is 'no gravity' or when the ships are in so-called zero gravity? As one self-confessed 'Star Wars Fanatic' wrote in the Sun newspaper:

> *"[s]ome Star Wars fanatics also got worked up about the opening scene, where we see a Resistance bomber dropping its payload to destroy a Dreadnaught…. how did the bombs fall in space, where there is no gravity, and how did the gunner, Paige Tico, survive opening the bomb doors to unleash the payload?"*

The website, *the Gamer*, went as far as to name this the seventh worst error in the movie:

> *"This whole space battle is happening in, well, space. And in space, there is no gravity. So how are bombs being released from bombers? Even if the door opens and the bombs are let loose, with no gravity to pull them down, they would just hover uselessly over the Dreadnought. It's a cool moment, don't get me wrong. But that still doesn't mean it makes sense."*

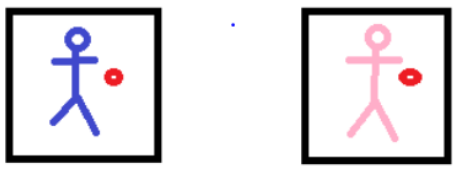
Clearly, it is a common belief that there is no gravity in space, but what creates this misconception?

For the sake of completeness, in what follows I'll refer to gravity as a 'force' when the theory of General Relativity showed that gravity should be considered as a distortion of space-time. The Newtonian description of gravity suffices for what follows.

So if there is gravity in space, why do astronauts float?

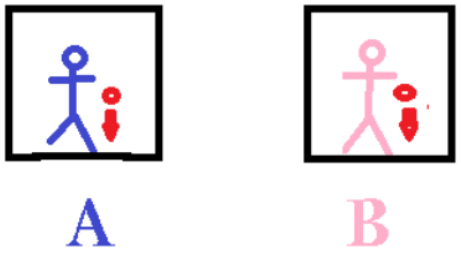
Probably the main reason why many people believe there is no gravity in space is that they have seen images, like the one above, of astronauts in orbit, floating, and heard the misleading term ‘zero-gravity’. Surely, the ability to hover mid-air implies not being under the influence of gravity, which most people view as making objects ‘fall’.

Imagine Ian and Astra are both in an elevator, one is on Earth and the cable has snapped and they are hurtling to their doom. The other is in orbit around the Earth in free-fall. Both have a ball and release it, finding that it does not accelerate to the floor. There is no way to conclude from inside the elevator which one is in which predicament.



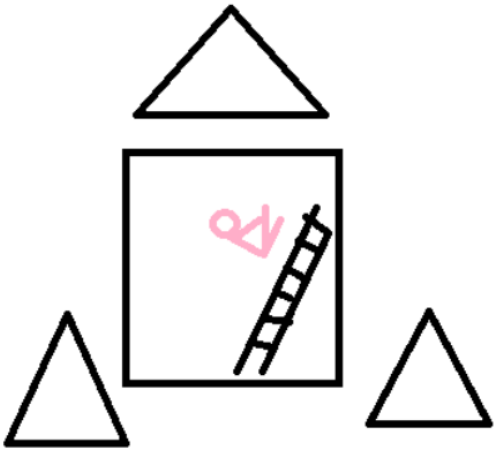
A B

Now imagine that the Earth-based elevator emergency brakes activate and at the same time the other elevator's rocket boosters activate. The Earth-bound elevator is still under normal gravity, whilst the space elevator accelerates upwards. Can Ian and Astra determine which one escaped which fate?

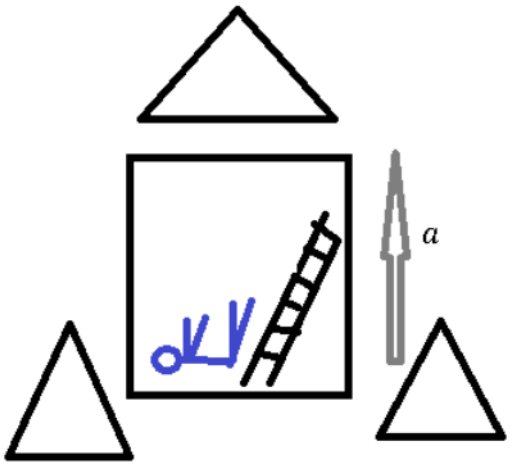


Now the released ball doesn't float, it falls, but is it falling because of gravitational force or because acceleration is pushing the floor up to meet it? There's still no way to tell who is where. All this led Einstein to conclude that acceleration and gravity are indistinguishable.

Imagine another astronaut, Stella, orbiting Earth in her rather crude looking ship. This time Stella is climbing a ladder in their ship when they slip. Instead of falling she hangs in mid-air.



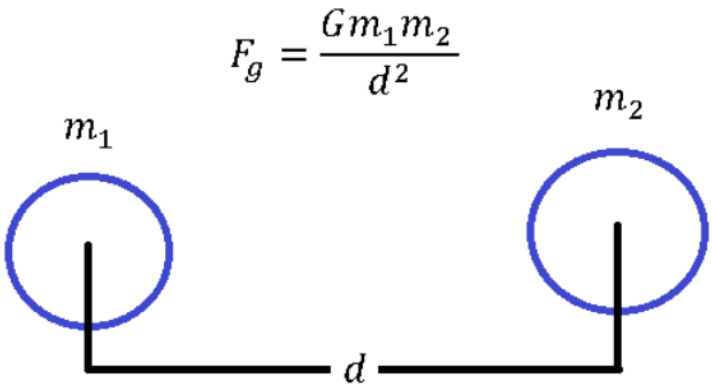
But the situation is different if the ship is accelerating. Hearing of Stella's ladder mishap, Bruce intends to replicate it. Unfortunately, he doesn't check if his ship's rockets are firing and it is thus accelerating first.



The truth is, astronauts, float because they are falling. They and the vessels they are in are in a perfect free-fall. They are falling 'around' the Earth — that's what an orbit is. They never reach the Earth because as they fall, as a result of the curvature of the earth, the surface of the planet is moving away from them at the same rate they are falling at. Gravity causes the spacecraft and all the objects in it to fall at the same rate, regardless of mass. This is why all the objects appear to be floating, they're actually all falling at the same rate.

So what about 'Zero Gravity'?

If there is gravity in space, why are objects in space often referred to as being in zero-gravity? Actually, the term is a complete misnomer. There is no physical body that isn't feeling the force of gravity at any point, but because gravity obeys an inverse square law, the further from an astronomical body an object is the less force it feels. In fact, it falls off incredibly quickly. But that doesn't mean that this force ever falls to zero.

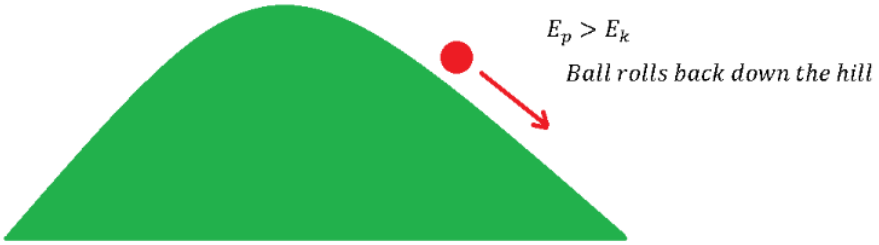


The term 'zero-gravity' is one that is so misleading that NASA themselves don't tend to use it anymore, preferring the more accurate term 'microgravity'. Objects in space may indeed be, for all practical intents, weightless, but it is vital to remember that weight and mass and different concepts. Gravity and acceleration act on mass to create 'weight'. It's also important to note that Newton's law of gravity applies to any bodies with mass, not just planets. moons or stars. The table in front of you exerts a gravitational force on you, it's just that its mass is way too small to have a significant effect on you. One could imagine that the First Order's huge star destroyers have quite a significant mass.

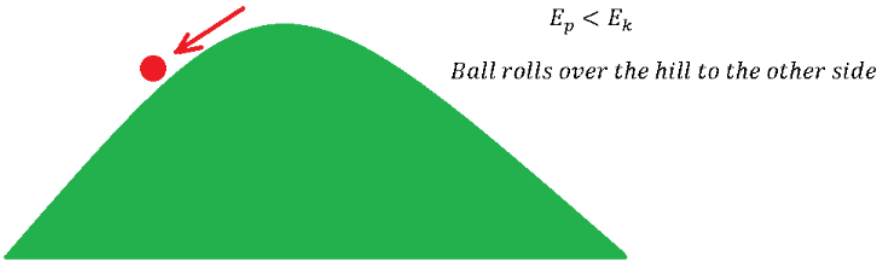
So, if material can 'fall' through space onto the surface of another object, does it ever actually happen?

The most obvious example of material passing through space from one body to another is the mass transference that occurs in a binary star system. A binary star system is a star-system of two stars orbiting around a mutual barycentre. It is approximated that 85% of the star-systems in the Milky Way are binary or triple-star systems, so our single-star system is less common than multiple star systems. A particular type of binary star system is the 'contact binary', in these star systems material can flow from one star to another, hence the name 'contact' despite the fact that the stars do not actually touch. All the material from one star needs to reach the other star is greater kinetic energy than the gravitational potential energy of the donor star.

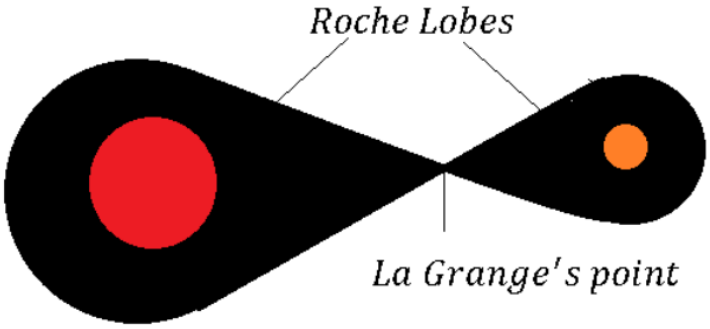
To picture this imagine a ball being rolled over the peak of a hill. All it needs to round the hill is the necessary kinetic energy to overcome the potential difference. If the potential energy is greater than the kinetic energy, the ball rolls back down the hill.



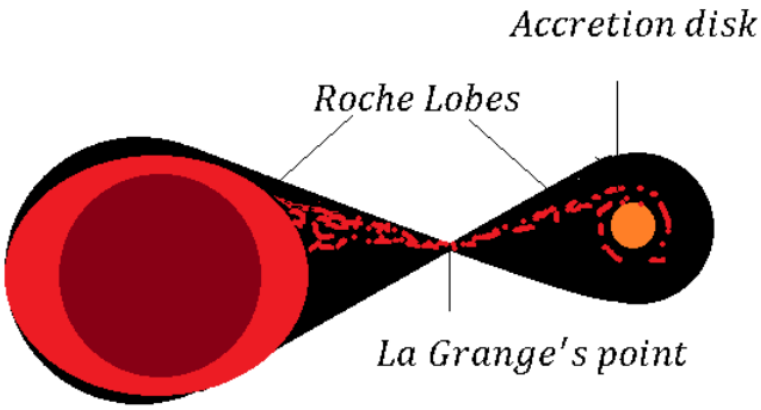
Whereas if the ball has the necessary kinetic energy, it rounds the top and falls to the opposite side of the hill.



The analogy for this potential difference between two stars in a binary system is called the Roche Lobe. The stars exist in an equilibrium between their relative masses.



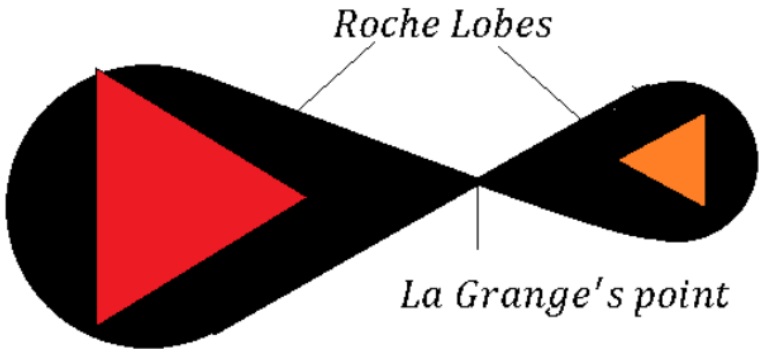
But if a star's radius extends beyond its Roche Lobe, material begins to flow through the La Grange's point to the companion star. This normally occurs when the larger star enters the 'red giant' phase of its lifetime, the shell of the star expands filling the Roche Lobe. Material is stripped from the larger star and passed to the smaller star through the La Grange's point. If there is a large amount of material, it forms an accretion disk rather than falling directly to the star's surface.



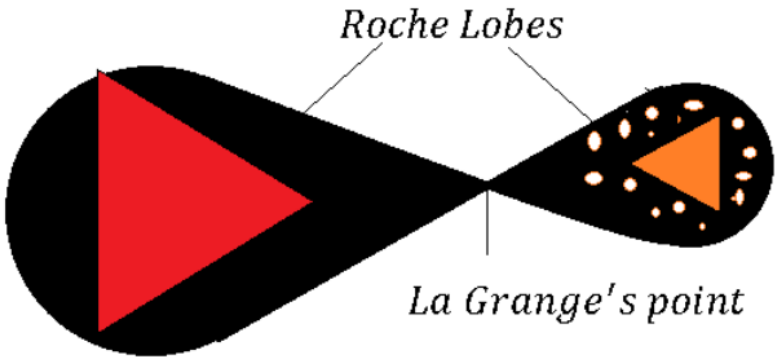
As the falling material loses angular momentum, it falls on to the companion star's surface. As this is occurring the violent forces in the accretion disk cause radiative emissions. They can actually be some of the most luminous objects in the universe and it is the emissions of accretion disks formed around black holes that have allowed us to see objects that themselves emit no light.

So how can we apply any of that to the 'Rebel bombers' in *Star Wars: The Last Jedi*?

Imagine the rebel bomber (orange) and the First-Order Star Destroyer (red) is occupying a similar gravitationally bound system. with the Star-Destroyer having the vastly greater mass.



How does the Rebel bomber get its deadly cargo to the Star Destroyer? It could release the bombs in such a fashion that they form a makeshift shell around the bomber. A shell that exceeds the Roche Lobe.



This would cause Roche Lobe overflow and allow the bombs to 'fall' onto the surface of the Star-destroyer. Not hovering so uselessly anymore!

So, it is not only possible to 'drop' material from one body to another in space, it is actually quite common despite there being no real concept of 'down'.

Conclusion, Nit-picking isn't criticism

Ultimately though, I'm not really sure I'll be thinking about any of this whilst I watch the latest Star Wars movie. When watching tales that ultimately centre around space-wizards, I tend not to worry much about physics.

If I hear a snort of derision from behind me during the 'bomber' scene though, I may well feel a twinge of sadness that at least one person in the theatre wasn't able to do the same. After-all doesn't the very first film in the series, *Star Wars: A New Hope*, feature sounds the X-wings and such make as they fly through space?

I don't recall too many critics calling that a flaw of that movie.

We all know that Hollywood films don't have great track records when it comes to accurately representing science on the silver screen.

Even movies that claim the title of science-fiction are most explicitly the latter and not the former. The key to tackling this lackadaisical attitude to actual science is the suspension of disbelief. There is no doubt that this is much easier to do in films with a completely fantastical setting than films which attempt to be based in the 'real-world'.

A good film establishes its tone early on, and as a result, we, as the audience, enter into an unspoken pact with the film-maker about to what level we must suspend our disbelief.

This is the reason that we are able to forgive the 'Asteroid-field chase' scene in 'Empire Strikes Back', but we can't forgive the statement about 'mutating neutrinos' in Roland Emmerich's pot-boiler enviro-disaster movie '2012'. Sure, asteroids in collections such as fields are extremely well-spaced, thousands of miles apart, but we ignore this because it's well established that Star Wars takes place in a magical universe where the laws of physics do not apply. Conversely, 2012 establishes itself in a world similar to ours, but with better teeth, thus we can't forgive a particle physicist applying a biological phenomenon to neutrinos; a fundamental particle much smaller than a gene!

When we watch a movie like *Star Wars* we enter a pact with the film-maker to suspend our disbelief. I feel like people break this pact when they don't like a film for reasons they can't express.

Science | Science Fiction | Star Wars | Space | Movies

159 claps

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Unit Resources and References

The resources are listed in the order that teachers will use them over the course of the unit.

Lesson 1

Video: What Do Physicists Do? https://www.youtube.com/watch?v=3Mo0sNANQT4

- This video provides students with background information about what a physicist is and what they do.

Video: The Physics of Space Battles https://www.youtube.com/watch?v=ZFOuxAx-dkc&t=228s

- This video examines the inaccuracies of the science seen in Star Wars battle scenes.

Instructional Resource: Balanced & Unbalanced Forces
https://www.generationgenius.com/wp-content/uploads/2018/03/Balanced-and-Unbalanced-Forces-Lesson-Plan-GG.pdf

- This resource provides a lesson plan for students to explore balanced and unbalanced forces from the Next Generation Science Standards. This document also provides teachers with activities on how to elaborate and evaluate this activity.

Instructional Resource: Gravity Activities and Games
https://www.generationgenius.com/wp-content/uploads/2018/03/Balanced-and-Unbalanced-Forces-Lesson-Plan-GG.pdf

- On this site, teachers will find a lesson plan to follow to lead a discussion and teach about gravity. Teachers can also find a follow-up activity where students write creatively , imagining life without gravity

Lesson 2:

Video: Mos Eisley - A New Hope https://www.youtube.com/watch?v=2P4Q50PiGCo

- This video provides footage from Star Wars: A New Hope of Luke Skywalker riding in his land speeder. This video is to provide students with background information of what a land speeder is.

Video: Star Wars - Return of the Jedi (1983) - Speeder Bike Chase
https://www.youtube.com/watch?v=uAjS-oyNjrg

- This video contains footage from Star Wars: Return of the Jedi and shows how Speeder Bikes, a form of landspeeder, move.

Video: Rey Speeder video clip https://www.youtube.com/watch?v=sDoSxywBT88

- This video from Star Wars: The Force Awakens shows Rey driving her land speeder providing students with information about how a landspeeder moves and what the point of view of the driver is.

Video: Science and Star Wars: Speeders and Hover Vehicles
https://www.youtube.com/watch?v=sDoSxywBT88

- In this episode of Science and Star Wars, scientists explore the real-world possibilities of creating hovercrafts on Earth. They also design a life size working model of Luke Skywalker's hovercraft.

Picture: Land Speeder https://starwars.fandom.com/wiki/Landspeeder

- This website was used to provide an image of a land speeder for the gallery walk

Picture: Rey's Speeder https://www.starwars.com/databank/reys-speeder

- This website was used to provide an image of a land speeder for the gallery walk

Picture: Skywalker vs. Stormtrooper Endor Battle Quadcopter Battler
https://www.starwars.com/databank/reys-speeder

- This website was used to provide an image of a land speeder for the gallery walk

Picture: Kom'rk Class Mandalorian Gauntlet Fighter by Ravendeviant
https://www.starwars.com/databank/reys-speeder

- This website was used to provide an image of a land speeder for the gallery walk

Lesson 3:

Background Information: http://www.physics4kids.com/files/motion_laws.html

- This site provides background information for teachers about Newton's Laws of Motion. It explains what each of the three laws states and provides examples of them.

Image: Rey and Kylo Ren Red Throne Room Battle:
http://www.physics4kids.com/files/motion_laws.html

- This image is used for the whole class discussion about what is seen and observed in the image. Students are asked to make observations and consider the forces that can be seen in the picture.

Image: Battle of Endor https://www.starwars.com/endor-history-gallery
- This is one image used by students in small groups or in Zoom breakout rooms to make observations about the forces they see

Image: Battle of Crait
https://starwars.fandom.com/wiki/Battle_of_Crait?file=Battle_of_Crait.jpg
- This is one image used by students in small groups or in Zoom breakout rooms to make observations about the forces they see

Image: Rey and Finn https://thecomeback.com/pop-culture/star-wars-the-force-awakens-begins-the-search-for-reys-family-tree.html
- This is one image used by students in small groups or in Zoom breakout rooms to make observations about the forces they see

Lesson 4

Video: Luke Skywalker vs. Darth Vadar (Whole Fight)
https://www.youtube.com/watch?v=U1MnMA0TzGI&t=9s
- This video is used to capture the interest of students. The video has many examples of different forces that students will be asked to identify and examine how Darth Vadar and Luke Skywalker use these forces to change the motion of objects.

Video: Leia Organa flies in space https://www.youtube.com/watch?v=6WzSdfKS1w4
- This video is of the scene where Princess Leia is pulled off of the bridge of her ship after an explosion and uses the force to bring herself back on board saving her life. The article the rest of the lesson is based on discusses this specific scene.

Article:
Lea, R. (2018, September 9). *Those scenes you hated in 'Star Wars: The Last Jedi' made total sense*. Medium. https://medium.com/@roblea_63049/those-scenes-you-hated-in-star-wars-the-last-jedi-made-total-sense-733750b1ba20

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