Science-ercise
Transforming the way we teach Science in schools

Science-ercise

Teacher Workbook

A project funded by the Ian Potter Foundation

Teacher Workbook Contents

OVERVIEW

Topic Physics for Kids: Making concepts simple

Aims

This 7 lesson unit is designed for upper primary students. It develops a working knowledge of the basic concepts, vocabulary and applications of physics in everyday life. The classroom experience and experiments will provide the aspiring scientists and engineers with the ability to recognize physics at work in daily life and to think about how to adapt the basics of physics into new areas of use.

Learning Outcomes

On completion of these lessons the student will be able to:

1.) Identify, describe and design examples of physics concepts in everyday life, such as the relationship between velocity, speed and time. The student will able to apply new knowledge to this understanding of these relationships.
2.) Confidently apply new vocabulary when explaining the physical manifestations of these concepts to others and in self-conceptualization. Begin to predict outcomes based on a new understanding of these manifestations.
3.) Develop an image of a career as a scientist, researcher and/or engineer capable of working in a field invested in the use of physics and other sciences. Be able to discuss why these professions have been important in
the past and what they might bring to the future.

Description of interactive activities to be undertaken

- Video presentation explaining vocabulary and basic concepts
- Video presentation to present and reinforce Twins Paradox concept of relativity of space-time
- Hands-On Discovery projects supported by eWorksheets with calculation to provide assessment solutions

Description of classroom activities to be undertaken

- Trajectory cars to test speed, velocity and time
- Nerf guns to reinforce concept of light waves
- Cannon shot to test trajectory, angle and distance
- Laser & hair experiment to test the particle properties of light
- Student workbook containing printed versions of worksheets that can be completed on paper and referred to post-class

Assessments

Informal vocabulary/concept mix-n-match will be given at the end of each class. Initial mix-n-match will provide baseline for pre-knowledge vocabulary. Subsequent min-n-match will add new concepts and words and asses each lesson plans effectiveness in introducing these concepts and terms. These assessments will be used to determine the topics for re-teaching in each subsequent day's introduction phase.

Lesson six will end with lively discussion and student participatory Q&A that reinforces the imaginary uses of physics concepts in the future (science-fiction appropriate), the many professional that depend on a working knowledge of physics and the possibilities of seeking careers in physics and other sciences.

Final assessment in lesson seven will include max-n-match as well as a quiz with simple calculations using concepts from classes and taken from daily worksheets and video presentations. Students will use a computer for this and an online questionnaire.

Context: Science-ercise modules support of ACARA learning descriptors:

1.) Motion

- The motion of objects can be described and predicted using the laws of physics (ACSSU229)
- Change to an object's motion is caused by unbalanced forces acting on the object (ACSSU117)
- Forces can be exerted by one object on another through direct contact or from a distance (ACSSU076)

2.) Light

- Light from a source forms shadows and can be absorbed, reflected and refracted (ACSSU080)
- On the atomic level, energy and matter exhibit the characteristics of both waves and particles (for example, Young's double slit experiment is explained with a wave model but produces the same interference pattern when one photon at a time is passed through the slits) (ACSPH140)

3.) Relativity

- Observations of objects travelling at very high speeds cannot be explained by Newtonian physics. (ACSPH129)
- Einstein's special theory of relativity predicts significantly different results to those of Newtonian physics for velocities approaching the speed of light (ACSPH130)

4.) Vocabulary pre-learned http://www.australiancurriculum.edu.au/Curriculum/Overview

Grade Level	Vocab Word
1-6 Geo 4 Science	Diffraction
1-6 Geo 4 Science	Distance
2-5 Maths	Mass
2-6 Dance	Space-Time
3 Science	Motion
3-4 P E	Acceleration
3-4 P E	Gravity
3-4 Science	Speed

Grade Level	Vocab Word
3-5 Science	Relativity
3-5 Science	Time
3-7 Science	Energy
5 Science	Wave
5-6 Science	Light
5-7 Math	Power
6 Science	Friction
6 Maths	Inertia

SCIENCE-ERCISE Lesson Plans 1-6 Overview

	Lesson 1 Velocity, Time & Distance(a)	Lesson 2 Velocity, Time & Distance(b)	Lesson 3 Trajectory & Angles	Lesson 4 Light as Particles & Waves	Lesson 5 Twin Paradox p. 1	Lesson 6 Twin Paradox p. 2
Introduction	Pre-assessment worksheet refreshing knowledge of previously learned terms and provides reference page for their workbook.	Introduce physics: stress importance and have students give examples of daily uses they recognise by relating to real-life settings.	Using LP3 vocab sheet reinforce pre-learned terms, LP1&2 terms and note new terms for LP3 : angle, collision, horizontal, momentum, trajectory, vector, velocity, vertical and Newton.	1) Intro vocab and concept of light as both wave and particle. Introduce Light as Particle terms: 2) Light as Waves- Laser diffraction measurements of a human hair: Referring to their worksheet, show the aerial photographs of ocean waves diffracting around an island.	Intro Twins Concept Space-time relative to spaceship. Use students to intro the basic confusion then proceed to addressing paradoxical confusion.	Reinforce Twins Concept Space-time relative to both and how there are multiple space times
Video	***5:05*** **Space & Time, pt1** Web video link; Local video link	***5:05*** **Space & Time, pt1** Web video link; Local video link	***4:49*** **Space & Time, pt2** Web video link; Local video link Pause video at selected interval to reinforce concepts	***3:27*** **Space & Time, pt3** Web video link; Local video link Pause video at selected interval to reinforce concepts. ***2:44 Laser Hair Test*** Web video link; local video link Plot keywords in video and provide paper notes to keep track of vocab and concepts.	***Show 2:37 of*** Web video link; Local video link ***1:20*** **60-Seconds in Thought: Intro to the TWINS** Web video link; Local video link ***5:03*** **Twin Paradox Demystified** Web video link; Local video link	***5:45*** **Physics Girl** Web video lInk; Local video link Plot keywords in video and provide paper notes to keep track of vocab and concepts. Confirm Concepts: View video and then recreate formula for calculating time of twins travel

Hands-On Discovery	Students work on worksheets individually but can refer to printed workbook vocabulary lists if overly challenged.	Hands-On Discovery using cars, batteries, tape measures and stopwatches/timers. Students use eWorksheets to record Discovery results.	Cannon Shot: trajectory, distance, angle concepts. Relate to LP1&2 velocity, distance and time Use student worksheets 5 'Cannon Shots' to introduce concepts of angle, momentum and trajectory in relation to velocity, time and distance. Students work in one group on eWorksheets but can compare answers if challenging.	1) Nerf Gun: Use student vocabulary worksheets 6 'Nerf Shots' to introduce concepts of light particles projecting around an object, spectrum, wavelength and relate to previous terms: angle, momentum, trajectory, velocity, time and distance. Students work in one group on worksheets but can compare answers if challenging. Nerf Gun shadows and form concepts about light as particles. 2) Laser light & Hair Test: Use a laser pointer as a source of waves, a human hair as an island and a screen as the shoreline. The similarity of the interference patterns demonstrates that light is indeed a wave. Students observe and measure the pattern of light and dark bands on the screen. We apply this measurement of the students own hair diameters by measuring patterns of light and dark.	With two students moving around the room, elicit the initial understanding of the concept. Pole-play the twin difference by speeding up and slowing down relative to one student or the other.	Move on to video and show in entirety. Note when relative measurement changes (reinforce relativity) and then remainder of time use and reuse formula
	Lesson 1 **Velocity, Time & Distance(a)**	**Lesson 2** **Velocity, Time & Distance(b)**	**Lesson 3** **Trajectory & Angles**	**Lesson 4** **Light as Particles & Waves**	**Lesson 5** **Twin Paradox p. 1**	**Lesson 6** **Twin Paradox p. 2**

Student Workbooks	Over-teach to cement Velocity, Time & Distance concepts in daily applications. Students split into smaller groups and complete printed work sheets Velocity and Distance in Student Work Books.	Students split into smaller groups and complete printed work sheets Time in Student Work Books. Students will also complete vocabulary notes for the days adding new terms they will use for future Discovery.	Students split into smaller groups. Use student workbook worksheet 'Projectile Motion' to support trajectory experimentation measuring and comparing how changing angles and using a relative velocity affects distance. Over-teach to cement concepts in daily applications. Relate Cannon Shot to the introduction of light as waves.	1) DRAW WHAT YOU SEE! Students split into smaller groups and "outline" plastic cans using Nerf gun foam bullets that are used to represent photons. Place a plastic can (or any object of good size) against a glossy wall or whiteboard. Step back no more than one meter and "illuminate" the object by shooting at least 10 Nerf bullets at and around the form. Remove the form and see the shadow pattern. Bullets stick only to the glossy surface, and create a silhouette of the form similar to how a light behaves around an object when it forms a shadow. 2) Using both eWorkbooks and student workboobk worksheets, calculate Laser light & Hair experiment and form concepts about light particles.	Consider Twin Paradox and identify, discuss and enter new terms to add to their Master Vocabulary List	Confirm Concepts: View video and then recreate formula for calculating time of twins travel. Use eWorkbook to find age difference for a number of twins in the student notebook.

Close	Q&A re: physics in everyday life and science fictions of future physics. Emphasize menial uses: from this morning on campus; bouncing a ball; running on the playground; punching a mate; etc.	Distribute single-page Mix-N-Match post-assessment with pre-learned vocab and new vocab introduced in LP1. If highly challenged, allow them to use their VOCAB MASTER worksheet list.	Q&A re: physics in everyday life and science fictions of future physics. Emphasize menial uses: from this morning on campus; throwing a basketball into the hoop (what are you estimating); punching a mate (angles and velocity) etc. Mix-N-Match – Distribute single-page Mix-N-Match post-assessment with pre-learned vocab and new vocab introduced in LP1, LP2 & LP3. If highly challenged, allow them to use their VOCAB MASTER worksheet list.	1) Q&A: emphasise that photons have properties analogous to the bullets, including momentum and discuss how this phenomenon is used by spacecraft using solar sails. Over-teach to cement concepts in daily applications. Relate Nerf Shot light particles to the introduction of light as waves. Briefly talk about the contributions of Galileo, Newton & Einstein in relation to their daily lives. Mix-N-Match post-assessment with selected vocab to date. If highly challenged, allow them to use their VOCAB MASTER worksheet list. 2) Q&A: We also see light as a wave and the many uses of this for space-time and other forms of quantum measurements. Discuss light vocabulary: contraction, diameter, gravitational waves, magnitude, particles, relativistic motion, spectrum, stretch n squash, Space time, time dilation, wavelength, Einstein, Galileo & Lorentz.	Reshow any videos that help support student understanding of the concept. These may include videos from previous lesson on space bending, timelines, light as particle and waves, well as current videos on space-time and time dilation. Conduct lively discussion about twin paradox and what it implies for science fiction and facts. Dispel any inaccuracies while encouraging fantastic concepts. Reinforce new terms.	Reshow any videos that help support student understanding of the concept. These may include videos from previous lesson on space bending, timelines, light as particle and waves, well as current videos on space-time and time dilation. Conduct lively discussion Q&A on future of physics, importance of careers, etc.

MIX 'N MATCH VOCABULARY MASTER

GRADE LEVEL	VOCABULARY	DEFINITION	EXAMPLE
1-6 Geo/4 Science	Distance	Linear extent of space or the space between two points	Launceston to Hobart
3-7 Science/DTech/Geo	Energy	The ability to do work, measured in joules	Sun's rays
3 Science/2-6 Tech	Motion	the process of being moved	Moving chess pieces on a board
5-6 Science/DTech	Light	Electromagnetic wave visible to the human eye	Sun's rays
5-7 Maths/English/History	Power	Rate at which energy is used	The force that makes an engine move
5 Science	Galileo	16th Century Italian who observed solar movements	Theory of Basic Relativity
6 Maths/3 English	Inertia	The state of rest	A bear hibernating
3-5 Science/3 Maths/4-6 Geo	Relativity	Light and Time interacting in space	Motion depended on the relative velocity and position of the observer.
3-5 Ski/4-6 Geo	Relativistic Motion	Motion that is defined by the reference point	Throwing a ball in a moving car
3-4 Science/5-6 Tech	Speed	How fast an object moves relative to a reference point	Changing gears on a bike
3-5 Science	Time	Intervals from past to future	Clocks
LP2	Velocity	Rate of change in an object's position (speed + direction)	How fast a car speeds up when the gas pedal is pushed
6 Maths	Vertical	Positioned up and down like a flagpole	latitude
LP3	Angle	Measurement of distance between two intersecting lines usually is degrees	Corners of a triangle
LP3	Collision	Two objects bump causing the exchange of energy	Crash of two cars
LP3	Horizontal	Positioned flat, such as left-to-right	The Horizon
LP3	Newton	Gravity, 3 laws of motion & calculus	Dropped an apple from a tree
LP3	Trajectory	Path of a flying projectile of moving object	A missile launch path
LP3	Vector	This quantity has both magnitude and direction	The direction or course flown by an airplane
LP4	Diameter	the distance around an object	A closed circle
LP4	Einstein, Albert	Identified the speed of light	$E=MC^2$
LP4	Gravitational Wave	Ripples in the curvature of space time	Similar to the ripples of water after dropping in a stone
LP4	Lorentz, Hendrik	Conducted early work on special relativity	1902 Nobel Prize for Physics

LP4	Magnitude	A unit of measure of the size, extent or dimension of an object	The length of a raceway
LP4	Spectrum	The positions between two extreme points	Visible colour chart
LP4	Time dilation	Space-time	Twins Paradox
LP4	Wavelength	Distance between the crests of waves	Crests of a surfing wave

LESSON 1

Velocity, Time & Distance (a)

	Velocity, time & distance
Introduction	Settle class Pre-assessment worksheet refreshing knowledge of previously learned terms and provides reference page for their workbook. Distribute single-page Mix-N-Match post-assessment with pre-learned vocab and new vocab introduced in LP1. If highly challenged, allow them to use their VOCAB MASTER worksheet list. *Pre-learned terms: distance, Galileo, gravity, light, speed, time, & wave* Introduce physics: stress importance and have students give examples of daily uses they recognize by relating to real-life settings. Tell students to use these new terms as they perform today's experiments and to identify and enter example AS THEY UNDERSTAND AND RECOGNIZE THEM into their workbook vocab pages.
Video	***5:05* Space & Time, pt1** http://ed.ted.com/lessons/the-fundamentals-of-space-time-part-1-andrew-pontzen-and-tom-whyntie Pause video at selected interval to reinforce concepts. Plot keywords in video and instruct students to add new vocab words from the video to their VOCAB MASTER worksheet list.
Hands-On Discovery	Students work on eWorksheets individually but can refer to printed workbook vocabulary lists if overly challenged.
Student Work Books	Students split into smaller groups and complete printed work sheets Velocity and Distance in Student Work Books. Over-teach to cement Velocity & Distance concepts in daily applications. Students will also complete vocabulary notes for the days adding new terms they will use for future Discovery.
Discussion & Close	Q&A re: physics in everyday life and science fictions of future physics. Emphasise menial uses: from this morning on campus; bouncing a ball; running on the playground; punching a mate; etc.

LESSON 1

MIX 'N MATCH - PRE-LEARNED VOCABULARY

	VOCABULARY WORD
1	TIME
2	SPEED
3	GALILEO
4	GRAVITY
5	DISTANCE
6	LIGHT
7	WAVE

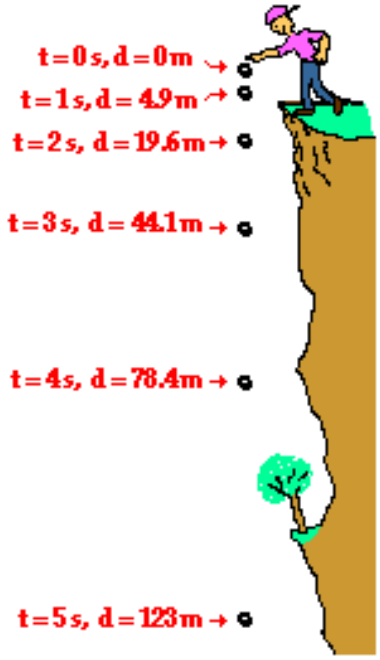
	DEFINITION	EXAMPLE
3	16th Century Italian who observed solar movements	Theory of Basic Relativity
1	Intervals from past to future	Clocks
6	Electromagnetic wave visible to the human eye	Sun's rays
5	Linear extent of space or the space between two points	Launceston to Hobart
2	How fast an object moves relative to a reference point	Changing gears on a bike
4	This force pulls an object downward	Dropping a ball from above the ground
7	Disturbance that travels through space and matter transferring energy from one place to another.	Sounds, lights and microwaves are examples. They transfer energy not matter.

LESSON 1

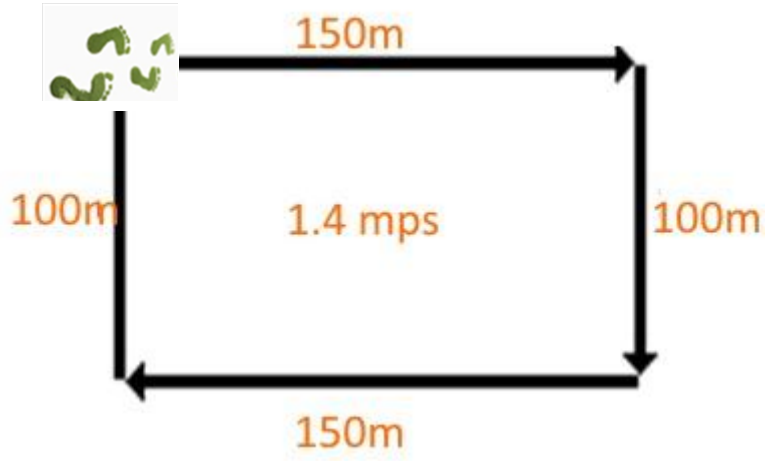
$$\textbf{VELOCITY} = \frac{distance}{time}$$

You figure it out:

$v = \frac{0}{0}$	0
$v = \frac{4.9}{1}$	4.9
$v = \frac{19.6}{2}$	9.8
$v = \frac{44.1}{3}$	14.7
$v = \frac{78.4}{4}$	19.6
$v = \frac{123}{5}$	24.6



You take a walk around the block to calculate your average walking speed or *velocity*. You begin by walking 150 meters East, you then turn right and walk 100 meters South, then right again and go 150 meters West, and finally one more right turn and 100 meters North. You end where you began. Walking around the block has taken you 6 minutes (360 seconds). Write your average velocity or speed in meters per second in the centre of the block.



LESSON 1

DISTANCE $= velocity * time$

There are 4 airports shown on the map. Near what cities are they located?

1 BURNIE	2 Devonport	3 Launceston	4 Hobart

You figure it out: Use the formula above to calculate the DISTANCE between these city's airports.

DRIVING DISTANCE	
Burnie-Hobart	337.5km
Devonport-Hobart	210km
Burnie-Devonport	75km
Devonport-Launceston	97.5km
Launceston-Hobart	200km
Burnie-Launceston	170km

FLYING DISTANCE	
Burnie-Hobart	240km
Launceston-Hobart	161km
Devonport-Launceston	80km
Burnie-Launceston	150km
Devonport-Hobart	200km
Burnie-Devonport	75km

AIRPORT to AIRPORT – Time & Velocity (Speed)

BY CAR:	Burnie Airport	Devonport Airport	Launceston Airport	Hobart Airport
Burnie Airport	-	75kph/1hr	68kph/2.5hr	75kph/4.5hr
Devonport Airport	100kph/.75hr	-	75kph/1.3hr	70kph/3hr
Launceston Airport	85kph/2hr	65kph/1.5hr	-	80kph/2.5hr
Hobart Airport	90kph/3.75hr	84kph/2.5hr	100kph/2hr	-

BY PLANE:	Burnie Airport	Devonport Airport	Launceston Airport	Hobart Airport
Burnie Airport	-	124kph/.5hr	200kph/.75hr	320kph/.75hr
Devonport Airport	124kph/.5hr	-	160kph/.5hr	266kph/.75hr
Launceston Airport	200kph/.75hr	160kph/.5hr	-	215kph/.75hr
Hobart Airport	320kph/.75hr	266kph/.75hr	215kph/.75hr	-

Lesson 2

Velocity, Time & Distance(b)

Introduction	Introduce physics: stress importance and have students give examples of daily uses they recognise by relating to real-life settings.
Video	***5:05*** **Space & Time, pt1** Web video link; Local video link
Hands-On Discovery	Hands-On Discovery using cars, batteries, tape measures and stopwatches/timers. Students use eWorksheets to record Discovery results.
Student Work Books	Students split into smaller groups and complete printed work sheets Time in Student Work Books. Students will also complete vocabulary notes for the days adding new terms they will use for future Discovery.
Discussion & Close	Distribute single-page Mix-N-Match post-assessment with pre-learned vocab and new vocab introduced in LP1. If highly challenged, allow them to use their VOCAB MASTER worksheet list.

LESSON 2

Velocity, Time & Distance (b)

$$\textbf{TIME} = \frac{distance}{velocity}$$

Race Game - You figure it out:

Racer #4 is averaging a speed of 60kph but Racer #7 is slightly ahead at 62kph.
Each HEAT is three laps. To win the race each Racer must complete 3 HEATS.
Complete the calculations before below:

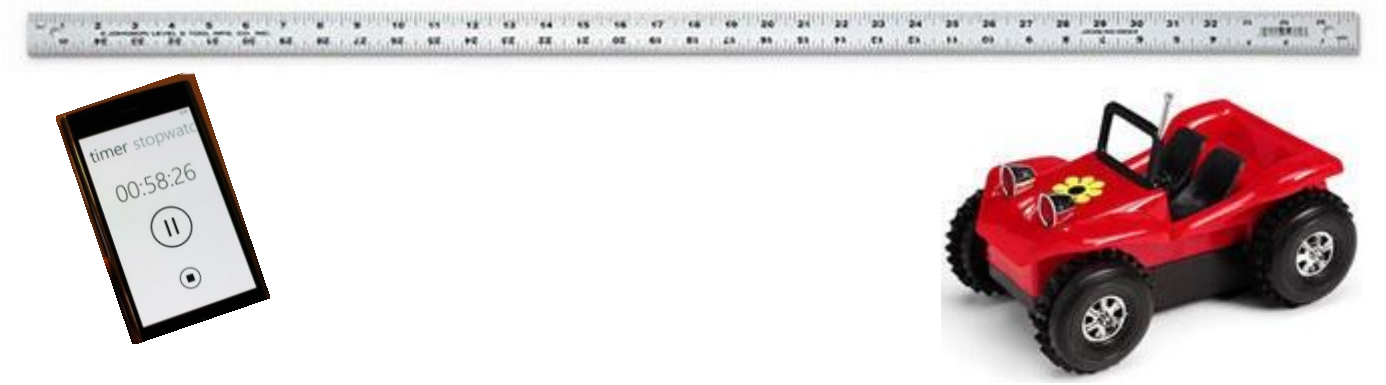
One lap around the Race Track is 38km.

RACE-TIME	Racer # 4	Racer #7	Difference
1 HEAT (3 laps)	1.9/hr	1.8/hr	.1/hr
3 HEATS - WINS THE RACE	5.7/hr	5.5/hr	.2/hr

On your mark… Get set… GO!!!!

LESSON 2

Let's measure the velocity!



You will need a measured track, a constant velocity car and your stopwatch or stopwatch app on your smartphone.

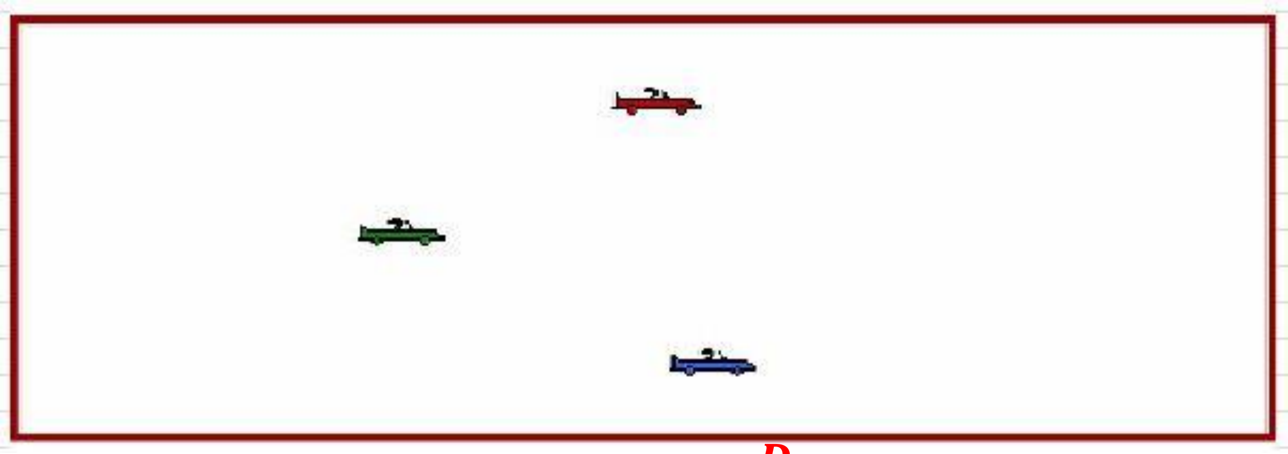
Place the front of the car next to the start of the measured track. As soon as the car moves, tap to start your stopwatch.

When the FRONT of the car gets to the end of the track, tap to stop the stopwatch.

Now you can use your eWorkbook to find the velocity of the car.

You can write the information from this experiment into the boxes on page 17. There are several for you to measure the velocity of several cars, or other moving objects.

LESSON 2



$$\textit{Velocity} = \frac{D}{t}$$

Experimental conditions
(for instance, red car on carpet going towards door)

Distance travelled (D)		meters
Time it took (t)		seconds
Velocity (v)=		m/s

Experimental conditions

Distance travelled (D)		meters
Time it took (t)		seconds
Velocity (v)=		m/s

Experimental conditions

Distance travelled (D)		meters
Time it took (t)		seconds
Velocity (v)=		m/s

Experimental conditions

Distance travelled (D)		meters
Time it took (t)		seconds
Velocity (v)=		m/s

Experimental conditions

Distance travelled n (D)		meters
Time it took (t)		seconds
Velocity (v)=		m/s

LESSON 2

MIX 'N MATCH

Lesson 1-2 NEW VOCABULARY

	VOCABULARY WORD
1	MOTION
2	INERTIA
3	FRICTION
4	LIGHT WAVE
5	DIFFRACTION

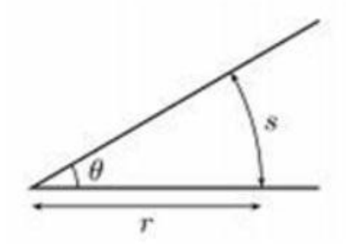
	DEFINITION	EXAMPLE
3	Resistance of motion when two bodies rub against each other	A car slowing down in a wind storm
5	A wave bending around an object	Light bouncing back from a mirror
1	the process of being moved	Moving chess pieces on a board
2	The state of rest	A bear hibernating
4	Electromagnetic wave measured in wavelengths	Sun's rays

LESSON 3

	Trajectory & Angles
Introduction	Settle class Using LP2 vocab sheet reinforce pre-learned terms, LP1 and 2 terms and note new terms for LP3: angle, collision, horizontal, momentum, trajectory, vector, velocity, vertical and Newton. Tell students to use these new terms as they perform today's experiments and to identify and enter example AS THEY UNDERSTAND AND RECOGNIZE THEM into their workbook vocab pages.
Video	***4:49*** **Space & Time, pt2** http://ed.ted.com/lessons/the-fundamentals-of-space-time-part-2-andrew-pontzen-and-tom-whyntie Pause video at selected interval to reinforce concepts. Plot keywords in video and instruct students to add new vocab words from the video to their VOCAB MASTER worksheet list.
Hands-on Discovery	Cannon Shot: trajectory, distance, angle concepts. Relate to LP1 velocity, distance and time Use student worksheets 5 'Cannon Shots' to introduce concepts of angle, momentum and trajectory in relation to velocity, time and distance. Students work in one group on eWorksheets but can compare answers if challenging. Refer to student worksheet 4 (velocity/speed & distance/displacement) to present images differentiating these terms and continue to use the terms appropriately for the rest of the class time.
Student Work Books	Students split into smaller groups. Use student workbook worksheet 'Projectile Motion' to support trajectory experimentation measuring and comparing how changing angles and using a relative velocity affects distance. Over-teach to cement concepts in daily applications. Relate Cannon Shot to the introduction of light as waves.
Discussion & Close	Q&A re: physics in everyday life and science fictions of future physics. Emphasize menial uses: from this morning on campus; throwing a basketball into the hoop (what are you estimating); punching a mate (angles and velocity) etc. Mix-N-Match – Distribute single-page Mix-N-Match post-assessment with pre-learned vocab and new vocab introduced in LP1 & LP2. If highly challenged, allow them to use their VOCAB MASTER worksheet list.

LESSON 3

TRAJECTORY & ANGLES



$$\textbf{Velocity} = \sqrt{\frac{Dg}{\sin 2\theta}}$$ **Projectile motion**

1. Choose one of the three settings for the Cannon Trigger. This will determine the **POWER** of the cannon ball launch.
2. Choose either a large or small cannon ball. The large ball has more **MASS** than the small ball. Launching the large ball will require more **POWER** to go the same **DISTANCE** (D) as the small ball.
3. Set the **ANGLE (Θ)** of the cannon. This affects the **DISTANCE** the ball will travel.
4. Measure the **DISTANCE** the cannon ball travels.
5. These measurements allow you to calculate the initial **VELOCITY** of the cannon ball. The pull of GRAVITY (g) is also taken into account.

Launch ANGLE [ ] degrees
DISTANCE [ ] meters
VELOCITY [ ] m/s

Launch ANGLE [ ] degrees
DISTANCE [ ] meters
VELOCITY [ ] m/s

Launch ANGLE [ ] degrees
DISTANCE [ ] meters
VELOCITY [ ] m/s

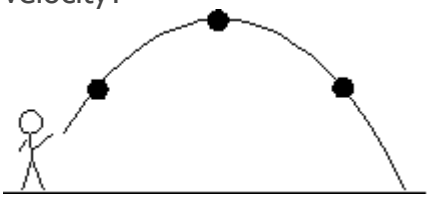
Launch ANGLE [ ] degrees
DISTANCE [ ] meters
VELOCITY [ ] m/s

Launch ANGLE [ ] degrees
DISTANCE [ ] meters
VELOCITY [ ] m/s

Launch ANGLE [ ] degrees
DISTANCE [ ] meters
VELOCITY [ ] m/s

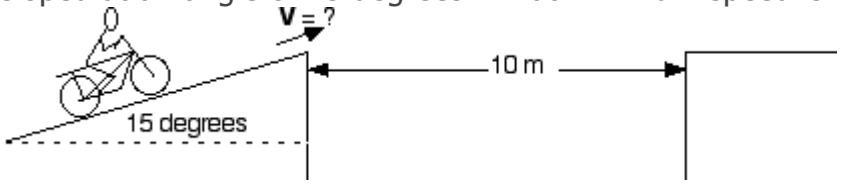
Projectile motion problems

A shotput is thrown and lands 34m away. If the launch angle was 48 degrees, what was its initial velocity?



Launch ANGLE	48	degrees
DISTANCE	34	meters
VELOCITY	18.31	m/s

A daredevil tries to jump a canyon of width 10 m. To do so, he drives his motorcycle up an incline sloped at an angle of 15 degrees. What minimum speed is necessary to clear the canyon?



Launch ANGLE	15	degrees
DISTANCE	10	meters
VELOCITY	14.01	m/s

This projectile is launched at an angle to the horizontal; it rises upward to a peak before falling back down.

A football is kicked with an initial velocity of 25 m/s at an angle of 45-degrees with the horizontal. Determine the horizontal distance travelled by the football.

Launch ANGLE	45.0	degrees
DISTANCE	63.7	meters
VELOCITY	25	m/s

A long jumper leaves the ground with an initial velocity of 12 m/s at an angle of 28-degrees above the horizontal. Determine the horizontal distance the long-jumper moves.

Launch ANGLE	28.0	degrees
DISTANCE	12.17	meters
VELOCITY	12	m/s

LESSON 3

MIX 'N MATCH
Lesson 3 NEW VOCABULARY

	VOCABULARY WORD
1	COLLISION
2	HORIZONTAL
3	NEWTON
4	VECTOR
5	VELOCITY
6	ANGLE
7	TRAJECTORY

	DEFINITION	EXAMPLE
7	Path of a flying projectile of moving object	A missile launch path
6	Measurement of distance between two intersecting lines usually is degrees	Corners of a triangle
1	Two objects bump causing the exchange of energy	Crash of two cars
3	Gravity, 3 laws of motion & calculus	Dropped an apple from a tree
5	Rate of change in an object's position (speed + direction)	How fast a car speeds up when the gas pedal is pushed
4	This quantity has both magnitude and direction	The direction or course flown by an airplane
2	Positioned flat, such as left-to-right	The Horizon

LESSON 4

	Light as Particles
Introduction	Settle class Intro vocab and concept of light as both wave and particle. Introduce **Particles** terms: contraction, particles, relativistic motion, space-time, time dilation, Einstein, Galileo & Lorentz. Tell students to use these new terms as they perform today's experiments and to identify and enter example AS THEY UNDERSTAND AND RECOGNIZE THEM into their workbook vocab pages. **Laser diffraction measurements of a human hair:** Referring to their LP4 worksheet, show the aerial photographs of ocean waves diffracting around an island. The images show the waves from both sides of the island creating a pattern of constructive and destructive interference on the shoreline behind the island. Reinforce vocab: contraction, particles, relativistic motion, space time & time dilation and ask students to watch for these words in the video.
Video	***3:27* Space & Time, pt3** http://ed.ted.com/lessons/the-fundamentals-of-space-time-part-3-andrew-pontzen-and-tom-whyntie Pause video at selected interval to reinforce concepts. Plot keywords in video and instruct students to add new vocab words from the video to their VOCAB MASTER worksheet list. ***2:44 Laser Hair Test*** http://education.jlab.org/frost/measure_hair.html Plot keywords in video and provide paper notes to keep track of vocab and concepts. May possibly reshow or continuous show during Discovery as a guide.
Hands-on Discovery	**Nerf Gun**: Use student vocabulary worksheets 'Nerf Shots' to introduce concepts of light particles projecting around an object, spectrum, wavelength and relate to previous terms: angle, momentum, trajectory, velocity, time and distance. Students work in one group on worksheets but can compare answers if challenging. Encourage students to be aware of using the terms appropriately for the rest of the class time. **Laser light & Hair Test**: Use a laser pointer as a source of waves, a human hair as an island and a screen as the shoreline. The similarity of the interference patterns demonstrates that light is indeed a wave. Students observe and measure the pattern of light and dark bands on the screen. We then apply this to measurement of the students own hair diameters by determining the position of the first dark fringe. Hair diameter is given by laser wavelength x distance from the hair to the screen/ dark fringe distance from central maximum. In this way students use the wavelike properties of light to compare each other's hair in an enjoyable and engaging activity.
Student Workbooks	**Nerf Gun shadows** and form concepts about light as particles. DRAW WHAT YOU SEE! Students split into smaller groups and "outline" plastic cans using Nerf gun foam bullets that are used to represent photons. Place a plastic can (or any object of good size) against a glossy wall or whiteboard. Step back no more than one meter and "illuminate" the object by shooting at least 10 Nerf bullets at and around the form. Remove the form and see the shadow pattern. Bullets stick only to the glossy surface, and create a silhouette of the form similar to how a light behaves around an object when it forms a shadow. eWorkbook and student workbooks: calculate **Laser light & Hair experiment** and form concepts about light particles.
Discussion & Close	1) Video: http://ed.ted.com/lessons/particles-and-waves-the-central-mystery-of-quantum-mechanics-chad-orzel (limit to 2:00min) Q&A: emphasize that photons have properties analogous to the bullets, including momentum and discuss how this phenomenon is used by spacecraft using solar sails. Over-teach to cement concepts in daily applications. Relate Nerf Shot light particles to the introduction of light as waves in LP4. Briefly talk about the contributions of Galileo, Newton & Einstein in relation to their daily lives. 2) Video: Why understanding Light is important & what it teaches us http://ed.ted.com/lessons/what-light-can-teach-us-about-the-universe-pete-edwards Q&A: We also see light as a wave and the many uses of this for space-time and other forms of quantum measurements. Discuss light vocabulary: contraction, diameter, gravitational waves, magnitude, particles, relativistic motion, spectrum, stretch n squash, Space time, time dilation, wavelength, Einstein, Galileo & Lorentz. Mix-N-Match – Distribute Mix-N-Match. If highly challenged, allow them to use their VOCAB MASTER worksheet list.

LESSON 4

LIGHT as PARTICLES

DRAW WHAT YOU SAW!

BEFORE	AFTER

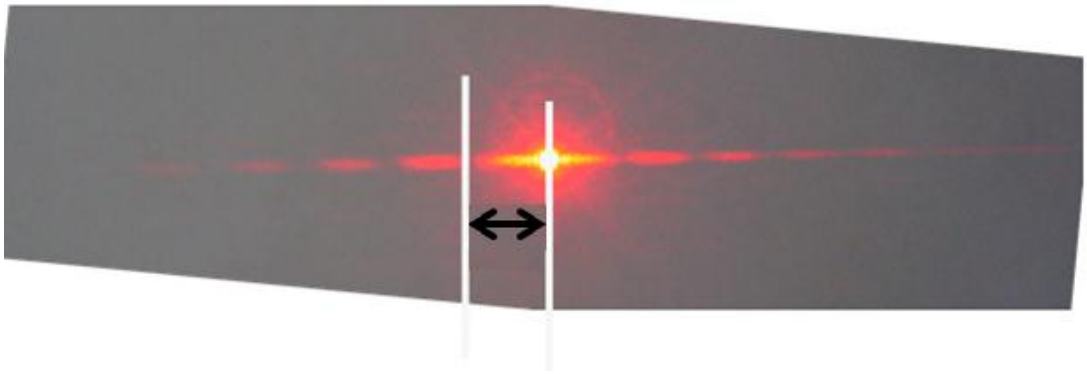
1. Place the plastic can in front of the whiteboard.
2. Stand 1meter from the board and shoot 8-10 NERF darts at the object. Some of the darts will stick to the can and other will stick to the whiteboard around the can.
3. In the BEFORE box, draw the can and make an ‘x’ in the places where the darts landed around the can.
4. Remove the can from the whiteboard.
5. In the AFTER box, mark an ‘x’ in the places where the darts remain.

The darts act like LIGHT PARTICLES. When light shines on an object, such as the can, the object keeps the light from landing on the surface behind the object. Instead the light lands on the area around the object. This creates a shadow image of LIGHT PARTICLES.

LESSON 4

LIGHT as WAVES

Using a Laser Light to measure a Hair



Measure from the centre of the bright spot to the centre of the 1st dark space on either side!

$$\text{Thickness of hair} = \frac{2\lambda D}{y}$$

RED LASER CALCULATION

Distance (D)		
Space between lines (y)		
Laser Wavelength (λ)	**650**	
Thickness of hair =		mm

GREEN LASER CALCULATION

		m
		mm
	532	**Nm**
Thickness of hair =		mm

Distance (D)		**m**
Space between lines (y)		**Mm**
Laser Wavelength (λ)	**650**	**nm**
Thickness of hair =		mm

Distance (D)		**m**
Space between lines (y)		**Mm**
Laser Wavelength (λ)	**532**	**nm**
Thickness of hair =		mm

LESSON 4

MIX 'N MATCH

Lesson 4 Waves NEW VOCABULARY

	VOCABULARY WORD
1	Diameter
2	Einstein, Albert
3	Gravitational Wave
4	Lorentz, Hendrik
5	Magnitude
6	Spectrum
7	Wavelength

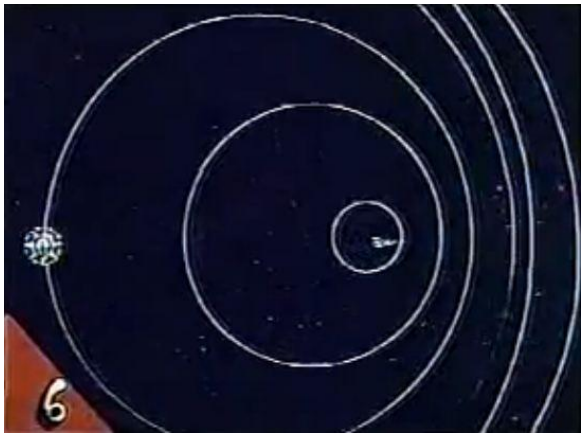
	DEFINITION	EXAMPLE
6	Visible colour chart	The positions between two extreme points
7	Crests of a surfing wave	Distance between the crests of waves
5	The length of a raceway	A unit of measure of the size, extent or dimension of an object
3	Similar to the ripples of water after dropping in a stone	Ripples in the curvature of space-time
2	$E=MC^2$	Identified the speed of light
4	1902 Nobel Prize for Physics	Conducted early work on special relativity
1	A closed circle	the distance around an object

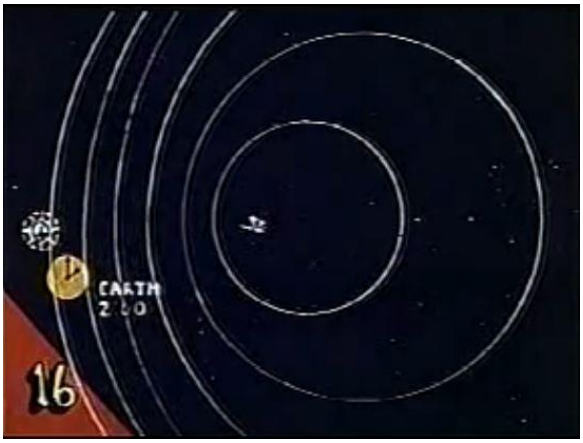
LESSON 5

	Twins Paradox Pt 1
Introduction	Settle class Intro Twins Concept Space-time relative to spaceship. Use students to intro the basic confusion then proceed to addressing paradoxical confusion.
Video	***Show 2:37 of*** http://ed.ted.com/lessons/how-fast-are-you-moving-right-now-tucker-hiatt ***1:20*** **60-Seconds in Thought: Intro to the TWINS** https://www.youtube.com/watch?v=oOL2d-5-pJ8 ***5:03*** **Twin Paradox Demystified** https://www.youtube.com/watch?v=8lh9AEP_e20 (show 2:37min)
Hands-on Discovery	With two students moving around the room, elicit the initial understanding of the concept. Pole-play the twin difference by speeding up and slowing down relative to one student or the other.
Student Workbook	Consider Twin Paradox and identify, discuss and enter new terms to add to their Master Vocabulary List
Discussion & Close	Reshow any videos that help support student understanding of the concept. These may include videos from previous lesson on space bending, timelines, light as particle and waves, well as current videos on space-time and time dilation. Conduct lively discussion about twin paradox and what it implies for science fiction and facts. Dispel any inaccuracies while encouraging fantastic concepts. Reinforce new terms.

LESSON 5

The Twins Paradox (Part I)





The ship sets out from Earth

The interval between flashes arriving on Earth gets greater, because the next flash has to travel further.

	On the Ship		*On Earth*	
At the start, what time is it on both clocks?	12:00	o'clock	12:00	o'clock
How many flashes does the ship send as it moves away?	10	flashes	10	flashes
How many minutes are there between each flash?	6	minutes	12	minutes
So the time from start to turn-around is	60	minutes	120	minutes
What time does the clock show at the 10th flash?	1:00	o'clock	2:00	o'clock

Now the ship turns round

The interval between flashes arriving on Earth gets smaller, because each flash has to travel less far.

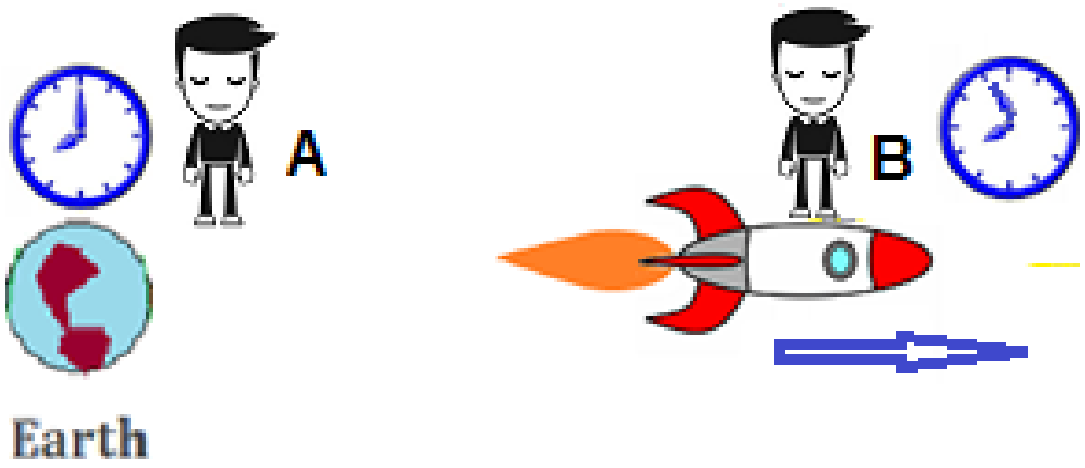
	On the Ship		*On Earth*	
How many flashes does the ship send as it returns?	10	flashes	10	flashes
How many minutes are there between each flash on the ship?	6	minutes	3	minutes
So the time from turn-around to the ship reaching Earth is	60	minutes	30	minutes
What time does the ship clock show at the last flash as it passes Earth?	2:00	o'clock	2:30	o'clock
Apparent time for the whole journey	2:00	hours	2:30	hours

LESSON 6

	Twins Paradox Pt 2
Introduction	Settle class Reinforce Twins Concept Space-time relative to both and how there are multiple space times
Video	***5:45*** **Physics Girl** https://www.youtube.com/watch?v=ERgwVm9qWKA Plot keywords in video and provide paper notes to keep track of vocab and concepts. Confirm Concepts: View video and then recreate formula for calculating time of twins travel
Hands-on Discovery	Move on to video and show in entirety. Note when relative measurement changes (reinforce relativity) and then for the remainder of class time use and reuse formula.
Student Workbook	Confirm Concepts: View video and then recreate formula for calculating time of twins travel. Consider Twin Paradox and identify, discuss and enter new terms to add to their Master Vocabulary List. Confirm Concepts: View video and then recreate formula for calculating time of twins travel. Use eWorkbook to find age difference for a number of twins in the student notebook.
Discussion & Close	Conduct lively discussion Q&A on future of physics, importance of careers, etc. Final assessment of Mix-N-Match vocabulary and computational formula

LESSON 6

TWINS PARADOX AGES



Age of the twins at start (A_s)	11	years	
Time the travelling twin is away (t)	2	years	
Speed of the travelling twin (v)	0.9	(% of speed of light)	
Age of Space-Travelling Twin	11.87	years	
Age of Earth-bound Twin	13	years	$A_s + t$
Age Difference	1.13	years	

Age of the twins at start (A_s)	12	years	
Time the travelling twin is away (t)	5	years	
Speed of the travelling twin (v)	0.9	(% of speed of light)	
Age of Space-Travelling Twin	14.18	years	
Age of Earth-bound Twin	17	years	$A_s + t$
Age Difference	2.82	years	

LESSON 7

Please administer the student test.

Each student will need access to a computer for this test.

In addition there is an online questionnaire.

http://bit.ly/science-ercise

OR

http://utaseducation.co1.qualtrics.com/SE/?SID=SV_eg2F5DRo2dL2KA5

RESOURCES

Council of the Australian Government. 2009. Pre-learned Vocabulary Words - http://www.australiancurriculum.edu.au/Curriculum/Overview

LP1 & 2: Velocity, Time & Distance
Video: ***5:05*** **Space & Time, pt1** http://ed.ted.com/lessons/the-fundamentals-of-space-time-part-1-andrew-pontzen-and-tom-whyntie Student Workbooks:
Velocity http://www.physicsclassroom.com/class/1DKin/Lesson-5/Acceleration-of-Gravity
Racetrack http://flashgames555.com/racing-games/Racing-Track.html
Tasmania Map http://aussiegetaways.com.au/packages/tasmania-fly-drive/
Race cars http://minisprintcarsforsale.blogspot.com.au/
Velocity Formula http://imgarcade.com/1/triangle-formula-for-speed/
Distance Flight Information http://www.distancesfrom.com/flight-time-from-Burnie-Airport-(BWT)-to-Devonport-Airport-(DPO)-Airport-Road/FlightTimeHistory/21866159.aspx?IsHistory=1&GMapHistoryID=21866159

LP3: Trajectory & Angle
Video: ***4:49*** **Space & Time, pt2** http://ed.ted.com/lessons/the-fundamentals-of-space-time-part-2-andrew-pontzen-and-tom-whyntie

LP4: Light as Particles
Video: ***3:27*** **Space & Time, pt3** http://ed.ted.com/lessons/the-fundamentals-of-space-time-part-3-andrew-pontzen-and-tom-whyntie
Nerf Gun image - http://nerf.wikia.com/wiki/2015
Nerf Gun Experiment - www.seeproject.org.au/includes/DOCS/einstein1.docx
Discussion: http://ed.ted.com/lessons/particles-and-waves-the-central-mystery-of-quantum-mechanics-chad-orzel (limit to 2:00min)
Light as Waves
Video: ***2:44 Laser Hair Test*** http://education.jlab.org/frost/measure_hair.html
Discussion: Why understanding Light is important & what it teaches us http://ed.ted.com/lessons/what-light-can-teach-us-about-the-universe-pete-edwards

LP5: Twin Paradox P1
Video: ***Show 2:37 of*** http://ed.ted.com/lessons/how-fast-are-you-moving-right-now-tucker-hiatt
1:20 **60-Seconds in Thought: Intro to the TWINS** https://www.youtube.com/watch?v=oOL2d-5-pJ8
5:03 **Twin Paradox Demystified** https://www.youtube.com/watch?v=8lh9AEP_e20
(show 2:37min)
eWorksheet: http://ed.ted.com/featured/yzGEPW1S

LP6: Twin Paradox P2
Video: ***5:45*** **Physics Girl** https://www.youtube.com/watch?v=ERgwVm9qWKA

Thank you for exploring Physics in Science-ercise!

The eWorkbook for Excel or Numbers on iPad can be downloaded from

http://www.science-ercise.edu.au