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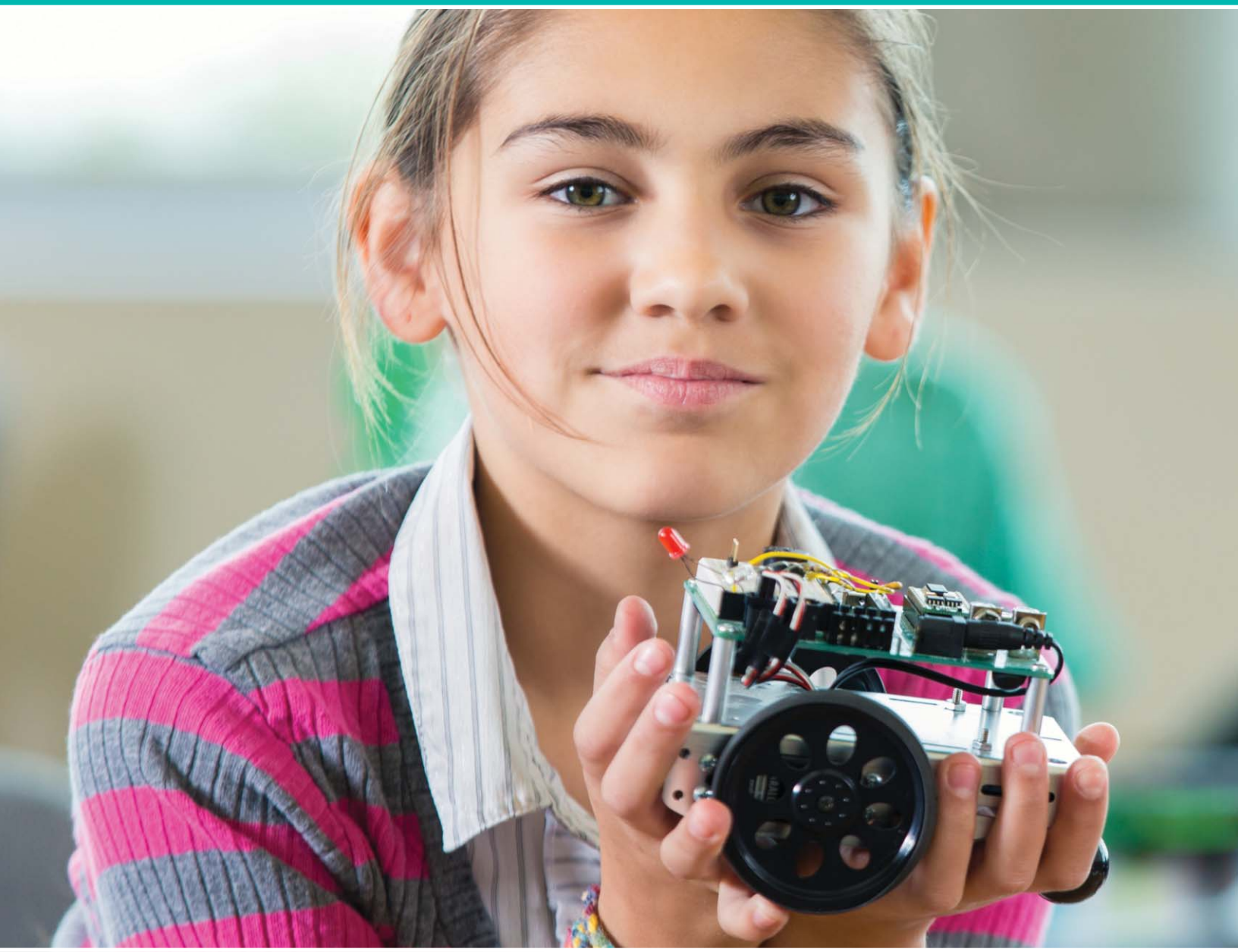

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Marbles, Physics, and Coding: A Twist on F=MA

Marbles, Physics and Coding: A Twist on F=MA

Incorporating play, forces and inquiry to introduce the fundamentals of coding.

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The Education Fund
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web site: www.educationfund.org

Table of Contents

Objectives

After the completion of the activities listed in this booklet, based upon content and Florida State Standards, the student will be able to:

SC.912.CS-CS.2.5
Evaluate classical algorithms and implement an original algorithm.

SC.912.CS-CP.2.6
Describe a variety of commonly used programming languages.

SC.912.CS-CS.2.10
Design and implement a simple simulation algorithm to analyze, represent, and understand natural phenomena.

SC.912.CS-CS.2.4
Divide a complex problem into simpler parts by using the principle of abstraction to manage complexity (i.e., by using searching and sorting as abstractions) using predefined functions and parameters, classes, and methods.

SC.6.N.1.5
Recognize that science involves creativity, not just in designing experiments, but also in creating explanations that fit evidence.

SC.6.P.13.3
Investigate and describe that an unbalanced force acting on an object changes its speed, or direction of motion, or both.

SC.6.P.13.1
Investigate and describe types of forces including contact forces and forces acting at a distance, such as electrical, magnetic, and gravitational.

Activity Overview

BACKGROUND: As a digital immigrant, I have always been amazed how seamlessly my students interact with their media and other digital devices. From networking and entertainment to finding answers to questions, today's youth were born tech savvy - yet only a few really understand how the technology works - from a traffic light at an intersection, or an app on a smartphone to an automatic defibrillator in a cardiac arrest.

As a result of the efforts of many tech pioneers, it has become possible – if not downright fun - for kids to get into the hearts and minds of the very devices they use to entertain them. It is called *coding* and the movement has infiltrated the educational system. The objective is to equip students with the knowledge and skills to improve global digital infrastructures - by the creation of innovative and powerful software programs and devices.

Coding, in its simplistic form, is a way of telling a computer what you want it to do. It involves creating and typing in step-by-step commands for the computer to follow. In most cases, computers are obedient - they will do exactly what you want them to do, as long as the directions are logical. In creating code, students become literate in new world languages – like C, Javascript or Perl. Each programming language has its own application much like French does in France and Mandarin in China.

Some say there will be nearly 1.4 million jobs in computer sciences yet less than half of university graduates will be qualified to fill them. But even in other professions, like medicine and finance, individuals will still need to have a basic understanding of programming and coding to interact with the digital tools of their trades.

As a digital immigrant, I understand the immense power and allure of computer programming. I also know the tactile and social voids that have been created by this new virtual reality. In a recent WSJ article, entitled *How Wooden Toys Teach Kids to Code, t*he question posed was whether an old-fashioned marble run was better than an iPad for teaching young children to code and why educational toys that focus on the social and physical world rather than the computer screen tend to be very effective.

The weaving of both these worlds became the focus of this activity…

Introductory Lessons

These introductory lessons are not mandatory to the success of the feature lesson but help fortify the concepts behind the problem solving nature of coding. They also review and clarify the foundations of physical laws, including Newton's Laws of Motion and Einstein's gravitational theory – to which everything on Earth is bound to.

Materials Needed
Copy/copies of *Lauren Ipsum*
5-10 *Code Master Programming Logic* Games
Copies of Force/Motion worksheets
Access to internet to view BrainPop Newton's Laws video

A) The Read Aloud*: Lauren Ipsum*

I transferred this book onto a PowerPoint presentation so that the whole class could be reading while students take turns reading aloud. The book can also be passed around. Afterwards, students offer their thoughts and points.
Lauren Ipsum is a great example of embracing computing fundamentals without the focus on computers themselves. Lauren is a girl who takes a whimsical journey through a land where logic and computer science come to life. She is an adventurer who gets lost in Userland and needs to find her way home. The only way to get home is to solve a series of puzzles. As she visits places like the Push & Pop Café and makes friends with people like Hugh Rustic and the Wandering Salesman, Lauren learns about computer science without even realizing it.

B) Code Master Programming Logic Game
https://www.youtube.com/watch?v=_LiTmpeWjlY

In the game of Code Master, students are provided with their own game. In the game, they are challenged to move their Avatar through an exotic world in search of power Crystals. There are 60 programming levels available to help the Avatar collect the Crystals and access the Portal. Thoughtfulness and problem solving are required in each level, because only one specific sequence of actions will lead to success. Although this is a single player, students can compete against each other. Multiple games need to be purchased to allow a group of students to play. The game includes 1 Avatar 1 Portal 6 Crystals 10 Maps Guide Scrolls Action Tokens and Conditional Tokens Instructions with Solutions.

C) Forces, Motion and Physical Laws (Worksheet 1 and BrainPop)

BrainPop: https://www.brainpop.com/science/motionsforcesandtime/newtonslawsofmotion/

F=MA worksheet:

F=ma

Name: _____

Warmup:

Force is measured in _____ and mass is measured in _____ and acceleration is measured in _____.

If we know the force exerted on an object (in Newtons) and we know the mass of the object (in kilograms) we can easily find the acceleration the object experiences by dividing the _____ by the _____.

If we know the force exerted on an object (in Newtons) and we know how fast the object accelerates (in m/s^2) then we can easily find the mass of the object experiences by dividing the _____ by the _____.

If we know the mass of an object in kilograms, and we know the acceleration that an object experiences then we can calculate the force exerted on that object by multiplying the _____ x _____.

1. An unbalanced force of 25 N in an Easterly direction is applied to a 12 kg mass. What will be the acceleration of the mass?

2. An unbalanced 16 N force is applied to a 2.0 kg mass. What is the acceleration of the mass?

3. A shot-putter exerts an unbalanced force of 140 N on a shot giving it an acceleration of 19 m/s^2. What is the mass of the shot?

4. An object moving with a constant velocity has an unbalanced force applied to it. If the unbalanced force is -20.0 N and the mass of the object is 3.75 kg, what is the acceleration of the object while this force is acting?

5. A racing car undergoes a uniform acceleration of 8.00 m/s^2. If the unbalanced force causing the acceleration is 6,000 N, what is the mass of the racing car?

6. How much force is needed to keep a 20 N stone from falling?

7. An economy car has a mass of 800 kg. What is its weight?

8. A small yacht weighs 14,700 N. What is its mass?

9. A 7.5 kg object is placed on a spring scale on the surface of the planet Nerdo. If the spring scale reads 78.4 N, what is the acceleration of gravity on Nerdo?

10. A car has a mass of 1200 kg. How much would the car weigh on the moon where the gravitational acceleration is 1.6 m/s^2?

11. You have a small rocket of mass 8000 kg sitting on its launch pad on Earth.

a. What is its weight? _____

b. What force is gravity pulling down on it? _____

c. If the rocket engine can produce a force of 10,000 N, what will be the net force acting on the rocket? _____

d. If the rocket engine burns for 10 seconds, how high up will the rocket be? _____

Featured Lesson Plan

Marbles, Physics and Coding: A Twist on F=MA

Incorporating play, forces, and inquiry to introduce the fundamentals of coding.

This middle school lesson includes a physics-focused marble design challenge and accompanying assessment sheet. This activity is followed by a variety of online coding program activities.

Materials Needed
Quadrilla Challenge marble run (1 kit per 4 students)
Marble run assessment sheet
Computers or tablets
Access to internet

Activity 1: The Marble Run

Employing hard wood blocks or wood marble runs give kids a wonderful opportunity to interact with each other while creating and problem solving given scenarios. In a very cool way, these old school materials offer a variety of lessons about the fundamentals of new age computer programming—specifically the art of debugging, which is all the more thrilling when a cascade of marbles is involved.

For this activity, students used the *Quadrilla Challenge* marble run kit. The tracks are intended to be level rather than pitched and the only time marbles can gain speed is when they fall through the holes of the colored blocks or when they slide down one of the small red ramps (accelerators). To keep the marbles moving – but not jumping off the track, students need to design it so that the marbles generate just enough momentum. Basic principles of physics (F=MA) are required here so that each marble has just enough force to accelerate its mass. Too little and it won't move, too much and it will fly off the track.

Students learn early on that their designs (whether original or one of the pre-designed examples) don't work perfectly at first. Like running a computer program for the first time, the

first marble launch will inevitably offer up some bugs in the track design. Some marbles will fly off the track because they've gained too much speed while others, lacking enough velocity, will stall.

The challenge:

Fixing—or debugging—each arrangement is not just fun, it is a great way to identify and correct problem points in the same manner as they might be faced with debugging a program.

A group of 4 students is given a *Quadrilla Challenge* kit and a set of parameters they must meet (height, length of run, number of drops, etc.). They are also given a preprinted sheet on which they describe their design and expected outcome. Following the proposal, the group is allowed one trial run with 10 marbles. Each group must document their observations and identify any/all problem areas (could be the presence or absence of accelerator, the height of the drop or the angle of a block). When the revisions are made, a sequential trial is run. This cycle of observation, discussion and revision continues until all 10 marbles successfully reach the collection area.

The assessment sheet

Marble Run Challenge Assessment: Members		
Describe/draw design		
Trial ONE Observations/Issues		
Revisions		
Trial TWO Observations/Issues		
Revisions		

Activity 2: CODING

Code.org https://code.org/starwars https://code.org/mc
https://studio.code.org/s/frozen/stage/1/puzzle/1 https://studio.code.org/flappy/1

Using the Code.org links above, students should attempt to complete the 4 self-directed coding activities over a series of classes. Using the principles in the introductory activities, students will design a program via trial and error. Once students are comfortable with the coding structure of the code.org activities, students may move on to the more involved ScratchED.

ScratchED https://scratch.mit.edu/projects/editor/?tip_bar=home
https://scratch.mit.edu/educators/

Students can use this initial interface so design simple to complex outcomes. I often give the students an open ended assignment - as complex as creating a fairy tale to something simple like make the object move in a circle. Students create their programs by dragging different script (costumes/sound) "puzzle pieces" onto the blank board to the right. They can change the character by changing the "sprite" (lower right).

- **Internet resources:**

http://www.wsj.com/articles/how-wooden-toys-teach-kids-to-code-1462463098

http://www.wsj.com/articles/toys-that-teach-the-basics-of-coding-1440093255

http://www.wsj.com/articles/SB10001424052702304709904579411354120634252

http://www.wsj.com/articles/new-ways-to-teach-young-children-to-code-1455049777

- **Materials /Prices**

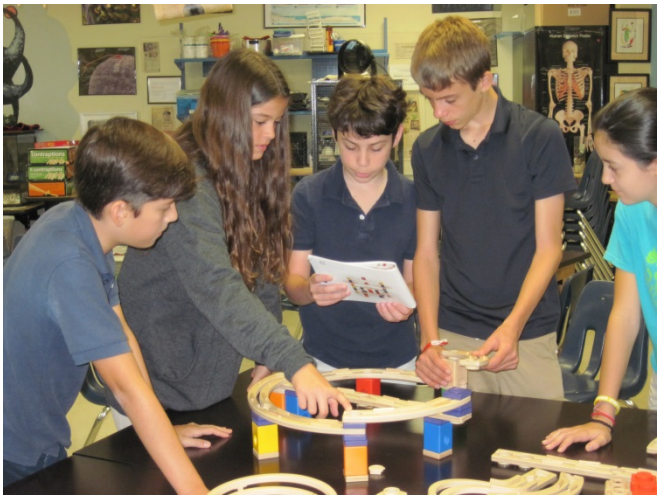
https://www.amazon.com/Hape-Quadrilla-Challenger-Wooden-Marble/dp/B00I1P4U98/ref=sr_1_1?ie=UTF8&qid=1465405864&sr=8-1&keywords=quadrilla+challenger

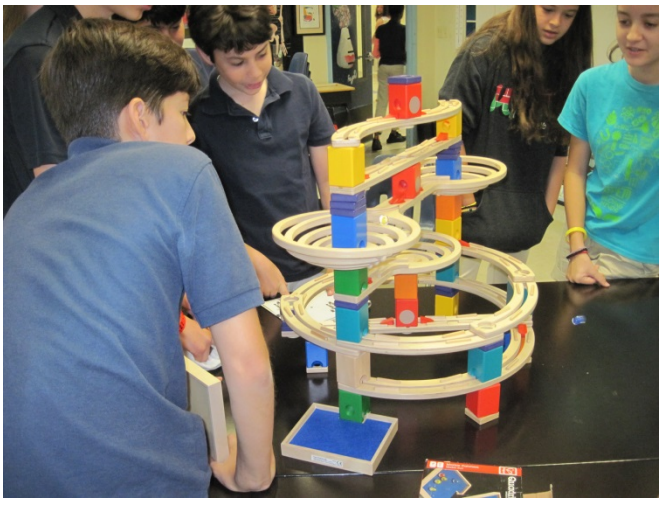
http://www.amazon.com/Lauren-Ipsum-Computer-Science-Improbable/dp/1593275749/ref=pd_sim_14_1?ie=UTF8&dpID=51uk8YMkqrL&dpSrc=sims&preST=_AC_UL320_SR214%2C320_&refRID=1HNB0S6EY04MKH38A22P

http://www.amazon.com/Coding-Games-Scratch-Jon-Woodcock/dp/1465439358?ie=UTF8&keywords=hopscotch%20coding&qid=1465314053&ref_=sr_1_fkmr1_4&sr=8-4-fkmr1

http://www.amazon.com/Code-Master-Programming-Logic-Game/dp/B014993TCI?ie=UTF8&keywords=coding%20board%20game&qid=1465315779&ref_=sr_1_1&refinements=p_72%3A2661618011&sr=8-1

Marble Run Photos





F=ma Worksheet

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Warmup:

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    a. What is its weight?

    b. What force is gravity pulling down on it?

    c. If the rocket engine can produce a force of 10,000 N, what will be the net force acting on the rocket?

    d. If the rocket engine burns for 10 seconds, how high up will the rocket be?

F=ma
F = force (N)
m = mass (kg)
a = acceleration (m/s^2)

When dealing with the acceleration due to gravity:

W=mg
W = weight (N)
g = acceleration due to gravity
($9.8\ m/s^2$ for surface of Earth)

Marble Run Assessment sheet

Names _____

Marble Run Challenge Assessment:		
Describe/draw design		
Trial ONE Observations/Issues		
Revisions		
Trial TWO Observations/Issues		
Revisions		

Pre-Activity Evaluation

Name _____

	0 None/not strong	1 Very little/not very strong	2 Somewhat/ slightly strong	3 A lot/very strong
Do you understand the purpose of coding?				
What has been your experience with coding/programming?				
What has been your experience with marble runs?				
How comfortable are you at solving problems?				
Do you think it is easy to tell a computer what to do?				

Before you begin this activity, please explain what you think problem solving is, what coding is and whether you think they are related.

Post-Activity Evaluation

Name _____

	0 None/not strong	1 Very little/not very strong	2 Somewhat/ slightly strong	3 A lot/very strong
Do you understand the purpose of coding?				
What has been your experience with coding/programming?				
What has been your experience with marble runs?				
How comfortable are you at solving problems?				
Do you think it is easy to tell a computer what to do?				

After completing this activity, please share your thoughts about how you view coding -

What does coding mean to you? Is the ability to problem solve a life skill (why/why not) and whether coding and problem solving are related.

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