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ANSWER KEY

Module 1 – Video Game Designer

1. The owner of the company explains that the language of physics is expressed using **algebra**.
2. To design a video game, the designer starts with something in the real world and writes a model for it. These models are written as **equations** that the computer can process, since the computer doesn't understand sentences like humans do.
3. The designer explains that the reflections of sun on ocean waves are modeled using a concept called the dot product, which involves two simple mathematical operations: **addition** and **multiplication**.
4. Word problems make the essential connection between math and the real world.
5. In your own words, explain the key message communicated by this Frogan's Hero. **Word problems seem impossible when you are first learning how to solve them, but it is like learning the alphabet as a small child. When you were a child, you never knew that you would be able to read so many cool words. Algebra is the fundamental step in the mathematical journey. But if you stick with it, and learn more, you will be able to do very cool things.**

Module 2 – Zookeepers

1. The zookeeper uses **algebra (or equations)** to calculate the quantities of **food** and **medicine** needed to keep animals healthy.
2. The calculations factor in several variables, including: **weight of the animal, growth of baby animals, and how many times they are fed each year**.
3. The mathematical models (equations) are used to determine how much food must be **ordered**.
4. Food quantities must be calculated carefully since, in some cases, orders for food are placed only once or twice each **year**.
5. In your own words, explain how the zookeeper uses algebra in her job. **Each month, the zookeeper must algebraically calculate the amount of food and medicine needed to keep many different animals healthy.**

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Module 3 – Firefighter

1. Name two of the variables mentioned as being important in the work of firefighting. **Answers might include: how close the buildings are to one another; number of personnel used to fight the fire; quantity of water used to fight a fire; fuel tank size; length of the hose; elevation of the hose; friction loss; hose diameter.**
2. Give an example of a formula mentioned by the firefighter. **Answers might include: Conversion formulas for temperature in degrees Fahrenheit to degrees Celsius or degrees Celsius to degrees Fahrenheit; formula to calculate the amount of water need to fight the fire; water supply formulas that determine how much water can be expected from each fire hydrant; friction loss formula.**
3. The further the water is pumped through a hose, the more **pressure** there must be to push the water through.
4. More pressure must be added to the water hose when the **elevation** of the hose increases.
5. In your own words, explain the key message communicated by this Frogan's Hero. **Putting out a fire is much more than spraying water on the fire. Many calculations have gone into** determining how to best do the job.

Module 3 – Astronomer

1. One variable that is important to these astronomers is the **diameter** of an object in space that may collide with Earth. An object with only a 20- or 30-meter diameter can produce a great deal of damage to the Earth. An object that measures one kilometer across can produce an event that affects the entire planet.
2. The astronomers take three **photographs** of the sky at night at intervals of 30-minutes so that they can determine if the object in space has **moved** in the course of sixty to ninety minutes.
3. The astronomers use **algebra** to compute how far an object should have moved in one day. This process is called extrapolation.
4. The formula $q = a(1- e)$ can be rearranged to solve for any of its three **variables**. These variables represent the closest approach to the sun, the semi-major axis of the orbit, and the eccentricity of the orbit.
5. In your own words, explain what these scientists do. **These scientists search for asteroids and comets near the Earth so that they can plot their movements to determine the likelihood of collision with Earth.**

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ANSWER KEY

Module 4 – Forestry Service

1. In your own words, explain what the scientist who works with deer does. **She is using non-lethal methods to reduce the deer population in Connecticut.**
2. To obtain a correct **baseline** for the number of deer in a region, the scientist must know the number of male deer, female deer and the number of fawns born each year.
3. The technique used by this scientist to for determine the number of deer that pass by the feeder is called, "mark-recapture". It involves using the **proportions** of deer caught that have tags and that do not have tags to calculate the number of deer on a particular property.
4. To maintain a particular population of deer, the birth rate and mortality rate of the deer must be kept **constant**.
5. The scientist who works with trees measures the diameter of each tree and its growth on a periodic basis so that he determines the tree's **annual growth** rate.
6. It would be too expensive and time-consuming to measure the growth of every tree in the forest, so the scientist uses a technique called sampling, along with algebra, to expand the projection to a larger number of trees. The scientist is able to use **algebra** to prove that the tree growth had improved by more than fifty percent.
7. Explain what the scientist who works with trees does in his job. **The scientist is finding ways to make trees grow faster and to prove scientifically that by treating the trees, he actually is achieving his goal.**

Module 5 – Skateboard Park Designer

1. This designer translates algebraic formulas and concepts into shapes for skateboard parks.
2. Skateboard parks are largely re-creations of elements found in the public, such as ramps, stairs, planters, seats, and benches. **Dimensions** and **proportions** of these are replicated in the skateboard park.
3. The concrete ramp on the blueprint is marked with a 3:1 **ratio**. This means that for each three feet in the **horizontal** direction, the ramp goes up one foot in the **vertical** direction.
4. The 3:1 ratio is used to determine that if the concrete ramp is ten feet long, then it must go up 3 feet, 4 inches. This mathematical process is an example of a **conversion (or scale).**
5. The designer believes that "knowledge is **power**". So having more knowledge *must* be cool!
6. What other things do you think could be designed using some of the same mathematical principals as are used to design skateboard parks? **Answers will vary. Some examples are buildings, streets, bridges, and parks.**

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ANSWER KEY

Module 6 – Pyrotechnician

1. According to the pyrotechnician in this segment, many people involved in pyrotechnics have an **artistic** background.
2. Two of the variables the pyrotechnician controls are **(possible answers include) heat, speed, light, danger, and sound**.
3. Sounds travels at a rate of 700 feet per **second**. This is an important number because it is used to calculate the **time** it takes for the sound of a firework to travel to the audience.
4. The **weight** of a firework is a variable factored into the calculation of how much lift is required to shoot the firework from the mortar tube into the sky.
5. In your own words, explain the key message communicated by this Frogan's Hero. **He enjoys his job very much, and his knowledge of algebra helps him do the job well. He uses math in his business all of the time.**

Module 7 – Music Amplifier Designer

1. Music on CDs and music played in the radio is **digitized**. The designer points out this word "digitize" comes from the word "digit", which just means "numbers".
2. Sound is shown as a waveform on a **graph**. The height of the waveform at different points in time is then represented with numbers.
3. In the past, guitar amplifiers have relied on **vacuum tube** technology. The designer can create new products that create new **sounds** by changing the numbers involved in the designs of the amplifiers.
4. The designer is using the problem solving techniques he learned in his high school **algebra** class.

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Module 7 – Stockbroker

1. What does this professional do in job? **She sells convertible securities; that is, she matches people who have money to people who need money**.
2. When dealing with other peoples' money, there is no room for errors or mistakes. The stockbroker must get the calculations right. If she were not accurate in her calculations, she would probably be **fired from her jo**b.
3. The stockbroker's graph shows that, in general, stock **prices** increase over time. So the broker suggests investing in stocks for the long-term.
4. The stockbroker demonstrated the use of a **proportion** when she calculated the price at which she should sell the stock that was originally purchased for $80 per share.
5. Explain why you think it might be interesting to be a stockbroker. (Answers will vary.)

Module 8 – Thrill Ride Engineer

1. The designer uses algebra to design the **slopes** and curves that get the vehicle from the top to the bottom of the track and to determine the spacing between ties on the tracks.
2. The more math is used in the design, the **cheaper** and **safer** the designer can make the rides.
3. What other things do you think could be designed using some of the same mathematical principals that are used to design rides? **(Examples might include: elevators, escalators, public transit, etc.)**

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Module 9 – Performance Car Designer

1. Describe what this Frogan's Hero does with the cars. **He modifies and reengineers Ford Mustang products so that they are high-performance customized vehicles**.
2. What are some of the variables involved in the modification of the vehicles? **Engine torque, engine horsepower, rpm of the motor, down force of the car, lift of the car.**
3. The computer is used to assist the designer in changing parameters that will affect how the car runs. The engineer changes numbers in the equations to make the **engines** do different things.

Module 9 – JPL Scientist

1. Briefly describe what this Frogan's Hero does in her job. **The scientist designs radios used for spacecraft navigation.**
2. The scientist estimates that 80% of the 5000 people who work at the jet propulsion laboratory use **algebra** regularly in their work.
3. A radio signal is sent to the spacecraft and then returned by the spacecraft to the earth. Based on the change in the signal caused by a "Doppler Effect", the scientists can determine how fast the **spacecraft** is moving.
4. According to the scientist, it is difficult to determine the location of the spacecraft because so many variables are involved, including the rotation of the **earth**, and motion of the spacecraft. These variables impact the frequency of the radio signal received from the spacecraft.
5. This scientist began to understand the power of **algebra** when her teacher was explaining the concept of ratios.
6. According to this Frogan's Hero, doing algebra at the jet propulsion laboratory is as essential as **breathing**.

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ANSWER KEY

Module 10 – Jet Fighter Pilot

1. The F-16 airplane can flies about 50,000 feet about the ground at a speed that is twice the speed of sound. This is called Mach 2, which is roughly **1000** miles per hour.
2. Before the pilot takes off, he spends 2-3 hours doing calculations. Name two of the variables the variables involved in the pilot's pre-flight calculations. **Answers might include: how much fuel per minute is used, how far the jet will travel, how much gas will be left when the jet arrives at its destination.**
3. According to the pilot, **algebra** is not hard, but it is disciplined. He says, "If you follow the rules, you will get the correct answers."
4. The pilot explains that the calculations related to fuel consumption and the ability of the pilot to reach the enemy with his weapons, he must be able to do the algebra in his head, while he is **flying**.

Module 11 – Civil / Structural Engineer

1. This Frogan's Hero explained that although **algebra** was difficult for her in the beginning, it got easy after practicing it more and more.
2. Sometimes in the field you have to draw the problem and solve it right there and then. She says that there is no substitute for being in the field, since a **calculator** will not tell you what is out in the field!
3. Mathematics is part of the job. You *must* to be able to use math and algebra to be an **engineer**.
4. Give some reasons why this Frogan's Hero enjoys her job so much. **She is excited about working on some of the most famous buildings being built in the country, including the Los Angeles Staples Center, where the Los Angeles Lakers play basketball. She also likes being "out in the field". She explained that being out "in the field" where the work will actually be done is very interesting to her – and can be challenging. She also likes her job because it is different every day.**

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ANSWER KEY

Module 11 – Signs of the Times Square Designer

1. Those in the industry call these special signs in Times Square, "Spectaculars". The "Hershey's Spectacular" is 215 feet tall and 100 feet wide. The designer used algebra to determine what it would take to hold the enormous 20-foot wide Hershey's cocoa cup using small **steel rails**.
2. The designer used a formula to determine the size and thickness of the steel beams. The formula is *moment equals force times* **distance**.
3. This Frogan's Hero did a bit of quick multiplication to determine how many panels of LED lights were being used on one side of a sign. 20 x 80 panels = **1600** panels.
4. Normal video is set up with a 4:3 aspect ratio, which is a ratio of the width to height of the picture. The aspect ratio for wide screen videos is 16:9. The aspect ratio for one sign described in the video is 4:1, which means that it is very **wide** and very short.
5. One of the designers explained that **algebra** seemed boring at first; but once he started realizing the applications, it became exciting.

Module 12 – Brookhaven National Lab Scientist

1. The laboratory houses a complex of particle accelerators to do research in particle physics. A particle accelerator speeds up the movement of atomic or subatomic particles. These particles can then be smashed into targets or into **each other** to see the effects.
2. The scientists at the lab are studying the **Big Bang**, what may have happened at the beginning of the existence of the universe.
3. How much current is in the machine at one time is determined using a tool called an oscilloscope. The scientist showed how to calculate an unknown quantity of current using a basic mathematical concept called a **ratio**.

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Module 13 – Rose Parade Float Designer

1. Describe why this Frogan's Hero must use equations in his job as a float designer. **Answers will vary. One possible answer is: The designer noted that about 25-30 roses per square foot are used, while only about 16 daisies per square foot are used. Thus, the types of flowers used and the area to be decorated are important variables in the equations that determine how many flowers of each type must be purchased.**
2. **Flower seeds** weigh a great deal when large quantities are used as decorations on the floats.
3. Creating spectacular parade floats requires hard work and lots of algebra, as this segment illustrates. The large number of flowers needed is calculated based on many variables. Name one of these variables. **Answer may include: area, number of surfaces, and the quantity of flowers per foot specified for each type of flower**.

Module 14 – Layout/Surveyor

1. This Frogan's Hero's job is to troubleshoot and to set up a construction job before it gets built. He says he coordinates the use of building materials like a **director** (or conductor) coordinates the use of instruments in an orchestra.
2. Using the measurements of length, width, and height, he calculated the volume of dirt to be removed to put in a retaining wall. Based on this quantity, he could then use **algebra** to determine how long it would take, how many people would have to work, and how much it would cost to do the job.
3. The project manager used the equation $x^2 + y^2 = d^2$, where *d* is the **distance** between the control point and the point where some other work on the project must be completed.
4. What other types of jobs might involve some of the same applications of algebra? **Answers will vary, but might include: architect, draftsman, civil engineer.**
5. **BONUS:** Look at the formula $x^2 + y^2 = d^2$ carefully. What famous theorem does this look like to you? Can you guess what the variables *x* and *y* what represent in the project manager's formula? **This looks like the Pythagorean Theorem. The variables x and y might represent the distances in the vertical and horizontal directions for the construction point to the control point**.

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Module 15 – Bronx Zoo Electrical Engineer

1. This Frogan's Hero's main job function is to maintain the zoo for the health and safety of the animals and the guests. Originally, he trained as an electrical engineer and was hired at the zoo to develop a **power generating plant**.
2. Describe the problem he used algebra to solve. **He used the formula P = VI (power equals voltage times current) to determine how much current would be needed to generate the amount of power needed in the zoo. This included calculating the current, determining what types of circuits to use, how many circuit to use, and what size wire would be needed to operate safely. He also had to take into consideration the fact that so much mor power is needed to operate the lighted decorations during the holiday season**.
3. What does this Frogan's Hero enjoy about his job? **Answers will vary, but might include: He enjoys his job because he likes to learn something new, likes to be a "hands on engineer", and likes to face new situations each day**.

Module 16 – Water Quality Chemist

1. Name one of this Frogan's Hero's primary job functions. Possible answers include: **to insure the quality and safety of the water provided to residents; to insure that the water meets state and federal water quality regulations; to insure that the water meets state and federal testing requirements**.
2. The chemist adds a chemical reagent to the water. The more chlorine is present in the water, the **pinker** the color.
3. Calcium and magnesium are measure in units of "parts per million". Other trace minerals are present in such small quantities that they are measured in units of parts per **billion**.
4. What example calculation did the chemist discuss to explain how she uses algebra in her job? **She discussed how she calculates the percentages of purchased water and local groundwater contained in blended tap water in her city.**
5. In her equation, x represents the percent of local groundwater contained in her blended sample. Using **algebra**, she determined that x = 0.39, or 39 percent.

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Module 17 – New York Film Maker

1. To edit the films, the filmmaker loads the footage into a computer. Name two of the variables involved in loading the footage onto a computer. **Answers include: the amount of storage space (hard drive space) available on the computer and how much footage he wants to load**.
2. Describe the calculation the filmmaker used as an example of how he uses algebra in his job. **He used an equation to determine if he has enough hard drive space to load all of the footage he wants to load onto the computer**.

Module 18 – Criminologist

1. What does this Frogan's Hero do in his job? **His job is to use science to investigate crime scenes to determine what happened and why it happened. Some of the crime scene "variables" this Frogan's Hero investigates include shoe impressions, ligatures used to bind persons, hairs and fibers, broken glass, background information about the person, and stains**.
2. This scientist measures the length of the droplet along its long axis and the width of the elliptical shape at its widest point. He then calculates the quotient of the **width** divided by **length**. The arcsine of that number gives an angle measurement in degrees.
3. The angle between each droplet and the place where it hit a surface is modeled using string. The place where the strings meet is the **point of convergence**, that is, the location the pattern originated.

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Module 19 – G.E. Wind Engineer

1. Wind energy has only recently become **economical**, but it is now cost-competitive with other types of energy.
2. New wind turbines are as tall as a 32-story building. They have three blades that work independently. The blades have a wingspan that is the size of a 747-jet! The swept area is equal to the area of a **football field**.
3. According to this Frogan's Hero, wind can produce enough power to meet the electrical needs of **The United States**.
4. This Frogan's Hero says that every business situation is translated into numbers and that the easiest way to do translate any situation into numbers is to create an algebraic equation. Some examples of questions she might answer using **algebra** include: How many wind turbines can be produced on what shift schedule? What level of productivity is she achieving over a year? What is the power output of the wind turbine?
5. She explained that the power output of a wind turbine is a **function** of cube of the wind speed and the square of the radius of the rotor diameter.
6. Why does she feel good about her job? **She is helping to provide power to the world with little or no environmental impact**.

Module 20 – U.S. Coast Guard Cadet

1. Three values of the Coast Guard are **honor, respect, and devotion to duty**.
2. Nautical science course is taken each year at the Academy. Algebra, trigonometry, and calculus are used to determine where the boat will be, given the variable of **time**.
3. One of the cadets points out that in the military, one must be prepared for what happens when the electricity goes out and, hence, the **computers** cannot be used. The cadets must know how to do the calculations by hand.
4. Another cadet points out that **algebra** is a cumulative subject. She explained that if you get lost in the subject early on, it might be quite difficult to catch up. She urges students to ask questions in class as soon as they don't understand a concept! "Don't be afraid, ask those questions!"