Name____ Date__________

Chapter 3

Performance Task

Algebra in Genetics: The Hardy-Weinberg Law

Some people have attached earlobes, a recessive trait. Some people have free earlobes, a dominant trait. What percent of people carry genetic information for both traits?

Part 1: Background

Algebra is everywhere—even in your genes! A famous equation called the Hardy-Weinberg Law can predict the number of people in large populations who carry certain genetic combinations. These combinations are called genotypes.

What is a genotype? Human beings have thousands of genes that determine characteristics such as eye color, hair color, and height. Each gene has different versions called alleles. For example, the ear lobe gene has an allele for free lobes, earlobes that hang below the point where they attach, and an allele for attached lobes. Humans carry two alleles, one from a mother and one from a father, for each gene. These two alleles together make up the genotype for a specific trait. The possible genotypes for free (***F***) and attached (***a***) earlobes are shown in the table.

		Paternal allele	
		F	*a*
Maternal allele	*F*	*FF*	*Fa*
	a	*aF*	*aa*

Because one allele is physically dominant, it is difficult to observe how many people carry *both* alleles. For example, a person with free lobes could have the ***FF*** genotype, *or* he or she could have the ***Fa*** or ***aF*** genotypes. The only thing that is known for sure is that the person with attached lobes carries the ***aa*** genotype and does *not* have both alleles.

Part 2: Creating the Model

So how can you know how many people carry both alleles? That is where algebra comes in!

Considering a **single** allele, let

p = the probability that a single allele is ***F***, dominant free lobes, and

q = the probability that a single allele is ***a***, recessive attached lobes.

a. The chance of an allele being either F or a is 100%. Complete the equation to represent this fact.

____ + ____ = 1

b. The probability of having the Fa genotype is represented by $p \bullet q$. What can you do to the binomial in part (a) to create an equation involving a term with $p \bullet q$? Use the sum in part (a) to complete the equation.

(____ + ____)$^{—}$ = 1$^{—}$

c. Expand the equation. This equation is known as the Hardy-Weinberg Law.

____ + ____ + ____ = 1

Chapter 3 Performance Task (continued)

Part 3: Understanding and Using the Model

In a population of 10,000 people, suppose that 80% have free earlobes and 20% have attached earlobes. Remember, you can observe only their *physical* traits. How can you calculate the number of people who carry *both* alleles?

a. Which genotypes comprise 80% of the population?

b. Which genotype comprises 20% of the population?

c. Find and interpret q^2. Explain your reasoning. Then find the probability that a single allele is ***a***.

d. Show how you can use your answer in part (c) to find the probability that a single allele is ***F***.

e. Find $2pq$ and explain its meaning in this context.

f. About how many people in this population carry *both* alleles? Explain.

Name____ Date__________

Chapter 3 **Performance Task (continued)**

Algebra in Genetics: The Hardy-Weinberg Law

Instructional Overview	
Launch Question	Some people have attached earlobes, a recessive trait. Some people have free earlobes, a dominant trait. What percent of people carry genetic information for both traits?
Summary	For genotypes with two alleles, the probabilities of the genotypes are represented by the equation $p^2 + 2pq + q^2 = 1$. This is known as the Hardy-Weinberg Law and is derived by squaring each side of the equation $p + q = 1$, where p is the likelihood of carrying a single allele and q is the likelihood of carrying the other. The task begins with an explanation of vocabulary and guides the student through the derivation. Then, using the example of free and attached earlobes, students calculate the probability of each genotype for a population.
Teacher Notes	One problem in genetics is that we cannot observe the number of people who carry one recessive gene and one dominant gene. We can only visually identify the number of people who carry two recessive genes, because that is the only genotype that will show the recessive trait. Everyone else has at least one dominant gene, but many have two dominant genes. From this large pool, we must identify the number of people carrying both dominant and recessive genes. The Hardy-Weinberg Law allows us to do this. This kind of calculation is critical in monitoring health issues like the number of people who carry a gene that makes them more susceptible to a certain disease or condition. Note that the existence of a single gene for free or attached earlobes has not been definitively established, and the example is used solely for illustration in this task.
Supplies	Calculators
Mathematical Discourse	If we look at a group of people with brown eyes, could we determine who also carried a gene for green eyes or blue eyes?
Writing/Discussion Prompts	**1.** Why is the ability to know how many people carry a certain gene important to world health? **2.** Explain why the only genotype we can identify by observation is whether a person carries two recessive genes for a certain trait.

Name ______________________________ Date __________

Chapter 3 Performance Task (continued)

Algebra in Genetics: The Hardy-Weinberg Law

Curriculum Content	
Content Objectives	• Create equations in two variables to represent relationships between quantities. • Find an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. • Use concepts of probability and independence.
Mathematical Practices	• Make sense of what is being asked before beginning to solve. • Use mathematical concepts to create a model. • Apply probability and an equation to analyze a population.

Rubric

Algebra in Genetics: The Hardy-Weinberg Law	Points
Part 2: **a.** $p + q = 1$ b. $(p+q)^2 = 1^2$ c. $p^2 + 2pq + q^2 = 1$	**3** 3 answers correct **2** 2 answers correct **1** 1 answer correct
Part 3: **a.** ***FF***, ***Fa***, ***aF*** **b.** ***aa*** **c.** q represents the probability that a single allele is ***a***, and q^2 represents the probability that two alleles are ***a***. Because ***a*** is the recessive trait $q^2 = 0.20$. The probability that a single allele is ***a*** is $q = \sqrt{q^2} = \sqrt{0.2} \approx 0.45$. **d.** $p + q = 1$, so $p + 0.45 \approx 1$ and $p \approx 0.55$ **e.** $2pq \approx 0.495$; $2pq$ represents the probability of having the ***Fa*** or the ***aF*** genotype. **f.** about 4950 people; The probability of carrying both alleles is 0.495. So, in a population of 10,000 people, about $0.495(10{,}000) = 4950$ people carry both alleles.	**7** All answers correct **5** Most answers correct **2** Few answers correct
Mathematical Practice: Make sense of problems and persevere in solving them. This component could be evaluated by interview or observation.	**2** For demonstration of practice; Partial credit can be awarded.
Total Points	**12 points**

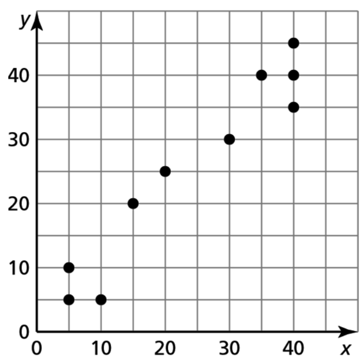
Name______________________________ Date __________

Algebra 2 Course Benchmark 1
For use after Chapter 3

1. Let $f(x) = 2x - 3$. Write a function g whose graph is a reflection in the y-axis of the graph of f.

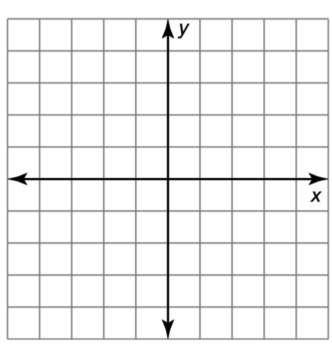
2. Your revenue (in dollars) for selling x hamburgers is given by $f(x) = 5x$ and your profit is \$20 less than 80% of the revenue. What is your profit for 88 sales?

3. Draw a line of fit for the data. Then write an equation of the line of fit.

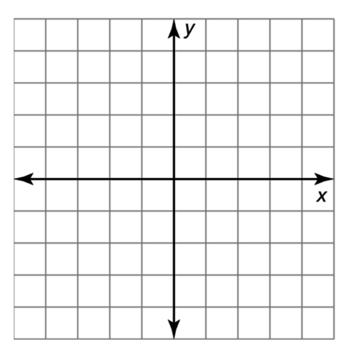


4. Solve the system $9x - 6y + 5z = 1$, $-2x - 8y + z = 10$, and $8x - 5y + 4z = 2$.

5. Graph $f(x) = -x^2 + 4x - 5$.



6. Graph $f(x) = (x + 1)(x + 3)$.



7. Write an equation of the parabola that passes through the point $(-9, 2)$ and has vertex $(-3, 1)$.

8. What is the average rate of change of $y = -2(x - 3)(x - 2)$ over the interval $0 < x < 2$?

Name ______________________________ Date __________

Algebra 2 Course Benchmark 1 (continued)

For use after Chapter 3

Solve the equation.

9. $2x^2 - 38 = 60$

10. $x^2 + 4x = 45$

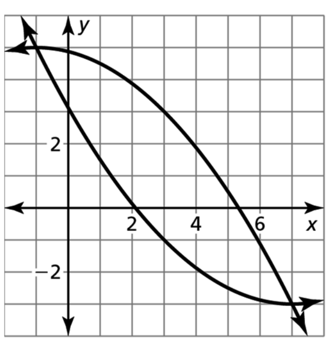
11. Find $\sqrt{-4}$.

12. Find $(7 - 8i)(4 + 8i)$. Write the answer in standard form.

13. Write $y = x^2 - 12x + 38$ in vertex form. Then identify the vertex.

14. Solve the system $x^2 + 14x - y = -51$ and $-2x^2 - 28x - y = 96$.

15. Solve the system using the graph.



16. Graph $y \le -2x^2 + 3x - 5$.