An Introduction to Actuarial Science

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Abstract: *Actuarial science is one of the fastest growing careers and continues to be named one of the best jobs in the US based on work environment, job outlook, security, and stress level. Many young people have heard that studying actuarial science can lead to a very good career, yet most have no idea what it entails. The purpose of this article is to introduce the field of actuarial science and to give some insight on what an actuarial scientist does and how to become one.*

Keywords: *actuarial science, piecewise functions*

1 Introduction

Actuarial science is one of the fastest growing careers in our modern society. The actuarial career continues to be named one of the best jobs in the United States based on work environment, job outlook, security, and stress level (US News, 2019). This profession continues to grow at a rate of 3.53% per year and currently has a workforce of over 10.9 million. The median salary for an actuary in 2018 was $102,880 per year (U.S. Bureau of Labor Statistics, 2019).

Many young people have heard that studying actuarial sciences can lead to a very good career, yet most have no idea what an actuary does. Teachers and parents are often unable to provide much guidance because they also do not know what actuarial science entails. The purpose of this article is to introduce both teachers and students to the field of actuarial science. But what IS an actuary? What does an actuary do? What will an Actuarial Science major study? What is the path to becoming an actuary? We will attempt to answer these questions and offer some suggestions for teachers to help high school students learn about this profession.

2 Definition and Job Description

An actuary is a person who uses mathematics, statistics and financial theory to measure, manage, and mitigate financial risk and uncertainty (US News, 2019). An actuary uses payment and claim information/data to determine the probability of an accident or another claim and the amount a person should pay in order to offset that cost/claim. They work with lots of data to develop a variety of models for insurance companies. One such model is shown in Figure 1 which displays a typical chart of the cost per month of getting $50,000 worth of life insurance (*note that coverage ends at age 80).

Benefit Amount: $50,000.00				
	Monthly Rates For: MALE		Monthly Rates For: FEMALE	
Age of Applicant	Non-Nicotine User	Nicotine User	Non-Nicotine User	Nicotine User
18–34	$8	$15	$7	$9
35–39	$10	$18	$8	$13
40–44	$12	$29	$11	$18
45–49	$17	$39	$13	$27
50–54	$27	$55	$18	$39
55–59	$41	$84	$25	$54
60–64	$59	$114	$37	$83
65–69	$91	$190	$59	$125
70–74	$153	$310	$101	$209
75–79*	$254	$506	$158	$337

Fig. 1: *AAA Life Insurance Chart* (`www.aaalife.com`).

3 Getting Started with Students: Noticing and Wondering

Using this chart, ask students to brainstorm mathematical questions it inspires. Before reading on, take a few minutes to do this yourself. What do you notice about Table 1? What do you notice about the numbers in this table? What do you wonder about this table? What types of mathematical questions could we explore?

3.1 Exploring the Table

After brainstorming, ask students to study the table and try to answer the following questions with their small groups. Hopefully, some of these same questions were discussed in the introduction to the lesson.

1. List at least three things that you notice about the chart.
2. Why do you suppose that it is cheaper for females to buy insurance than males?
3. Why would a nicotine user pay more for life insurance?
4. Name three reasons why you think that life insurance gets more expensive as you get older.
5. If you were a 25 year old, how much would you pay for $50,000 of life insurance?
6. Why do you suppose that the interval for age is 18-34, but after that it increases every five years?
7. Why is it so expensive to get life insurance when you are 75 years old?
8. Why can't you buy life insurance when you are 80 years old or older?
9. Why do you suppose that you can't purchase life insurance if you are younger than 18?
10. Does the cost of life insurance per month increase with age at a constant rate? Explain.
11. Do you think it is important to have life insurance? Why or why not?
12. At what age/time of life do you think it would be important to purchase life insurance?

Students might not be able to come up with answers to all these questions, but encourage them to do as well as they can. After about 10 minutes of letting them discuss the information in the table, bring the students back to a large group and ask various groups to share what types of answers they came up with for some of these questions.

3.2 Graphing and Analyzing

Following this introduction, ask the students how we might find out more about this table and the data it shows. Hopefully, someone will mention that we could graph it. Further discussion should ensue about whether this is a function or not, the type of function, its domain and range, etc. We've found that technology often plays a vital role in these types of follow-up investigations. For example, in considering Question 10 from the previous list, we found that using GeoGebra works well by using the FUNCTION command. Depending on the objectives of the lesson, a teacher could demonstrate by showing this graph using the link or students could recreate this graph on their own computers. The graph in Figure 2 shows the cost per month for both males (shown in blue) and females (shown in red) who are not nicotine users. After graphing the data, ask students what

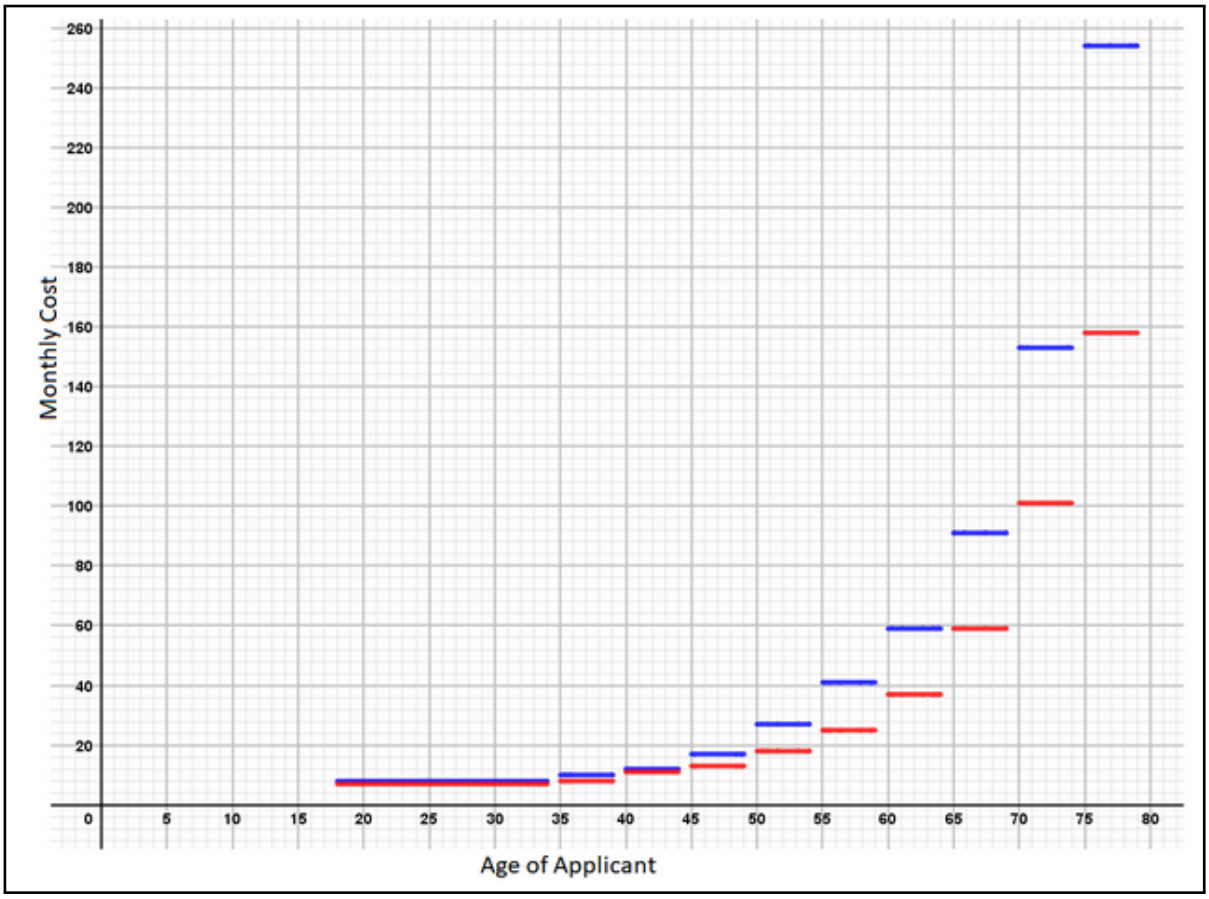

Fig. 2: *Monthly cost of life insurance* (`https://www.geogebra.org/graphing/v7rvdamt`).

they see and if it matches any of their original thoughts. Ask them if they recognize the type of function shown in the graph (answer: exponential step function). Challenge students to use the data from the chart to determine an exponential "best fit" function and graph it directly on the GeoGebra file they have already created. Note that we used a graphing calculator to do this part. A discussion can ensue about how to represent an exponential step function as well as how we might determine the equation of this exponential function. If we decide to use the first value for each age group as the domain, we come up with fairly nice exponential functions for non-nicotine users: $f(x) = 0.6(1.08)^x$ (males) and $f(x) = 0.65(1.07)^x$ (females).

Ask students what these functions mean. Basically, although the females and males start around the same value, their cost per month growth rate for every five years of life is different: 8% growth rate for males and 7% growth rate for females. *Is that difference a lot?*

See if students can graph the male nicotine user vs the female non-nicotine user costs on their own (See Figure 3). They will notice a STARK difference! A 75 year-old male nicotine user pays more than three times that of a 75 year-old female non-nicotine user-per month on life insurance! This is a difference of $4176 per year! This is a significant amount of money if you consider that many people live well into their eighties now.

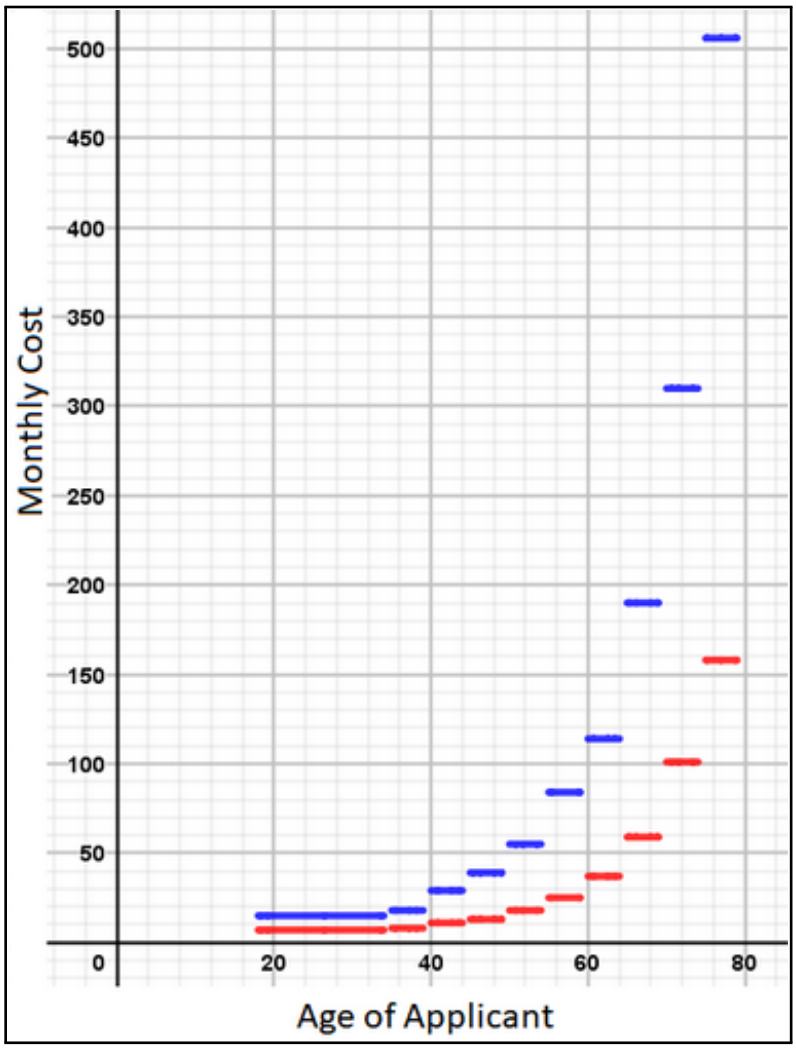

Fig. 3: *Monthly costs for male nicotine user (in blue) versus female non-nicotine user (in red)* (`https://www.geogebra.org/graphing/marq8fsj`).

See if students can also figure out the regression equations for these data. *What are the growth rates in this model?* The "best fit" equation for females is the same as provided in the example from Figure 2; the male equation is $f(x) = 1.2(1.08)^x$. Notice that this equation has the same growth rate as the male non-nicotine users, but its starting value is double. Besides the mathematics involved with this problem, now might be a good time to have a short discussion about the cost of smoking and the value in not smoking.

Hopefully, the activity thus far has piqued the interest of your students and reinforced some of the mathematical concepts you have been studying, maybe related to exponential functions. Now is a good time to ask students if any of them knows who decides these rates and how. *Has anyone considered majoring in Actuarial Science in college? What does an actuary do?*

4 What an Actuary Does

This is an interesting chart and set of data, but have you ever wondered how an insurance company determines these costs and how much you will pay for insurance? When you talk to the girl sitting next to you in class, you might find out that her car insurance is much cheaper than yours. If you talk to your parents, you might find out that they purchased life insurance, but they pay more than your friend's parents. How do insurance companies determine the price they will charge for insurance? They depend on actuaries to perform statistical analyses of past losses, based on specific variables of the insured (age, gender, risk factors, etc.) These variables are used, along with probability theory, to forecast events and help to set the premiums. Since you might have a few students interested in this field, you could share the information below about how they can become an actuary.

4.1 Path to Becoming an Actuary

When a student begins to study actuarial science in college, they will start with taking some mathematics classes, which will include Calculus, Probability Theory, and Statistics. They will also take courses in Business, Business Law, Economics, Information Management Systems, Finance, Marketing, Risk Management, etc.

There are two different paths to choose from once a student decides to become an actuary. The path chosen depends on the field in which the student desires to work. There are two organizations associated with this field. The first is The Society of Actuaries (SOA) which deals with life and health insurance. The second is The Casualty Actuarial Society (CAS) which deals with property and casualty insurance. Both societies require aspiring actuaries to pass a series of exams, and the total number of exams depends on which society is chosen. Some exams are required for both groups. See the chart below for the exams that are required in each society. A person studying to be an actuary typically takes one or two exams while pursuing their undergraduate degree. After that, the student will be hired by a company as an assistant actuary and trained in their designated area of expertise. Most of the time the company will prepare and pay for the assistant actuary to take the other exams. Once the assistant actuary passes all the exams and other requirements, they become a certified actuary. Based on the average experience of actuaries, it can take 6-10 years to pass all the exams.

5 Conclusion

In 1889, the total actuarial population on this continent numbered between 80 and 100 persons. The profession's heritage in North America had been built upon European foundations dating back to the establishment of probability theory in the mid-seventeenth century and dealing exclusively with life insurance. Over the years, actuaries moved from providing life insurance to health insurance and then to providing car insurance. Actuaries most recently even provide models for government, public health, education, technology, finance, and judicial systems.

The field has grown tremendously in the past century. There are currently 134 colleges and universities with actuarial science programs in the United States. The U.S. Bureau of Labor Statistics projects that there will be a 20% increase in the job outlook for actuaries between 2018-2028 (Bureau of Labor Statistics, 2019). Obviously, the future is bright for an aspiring actuary.

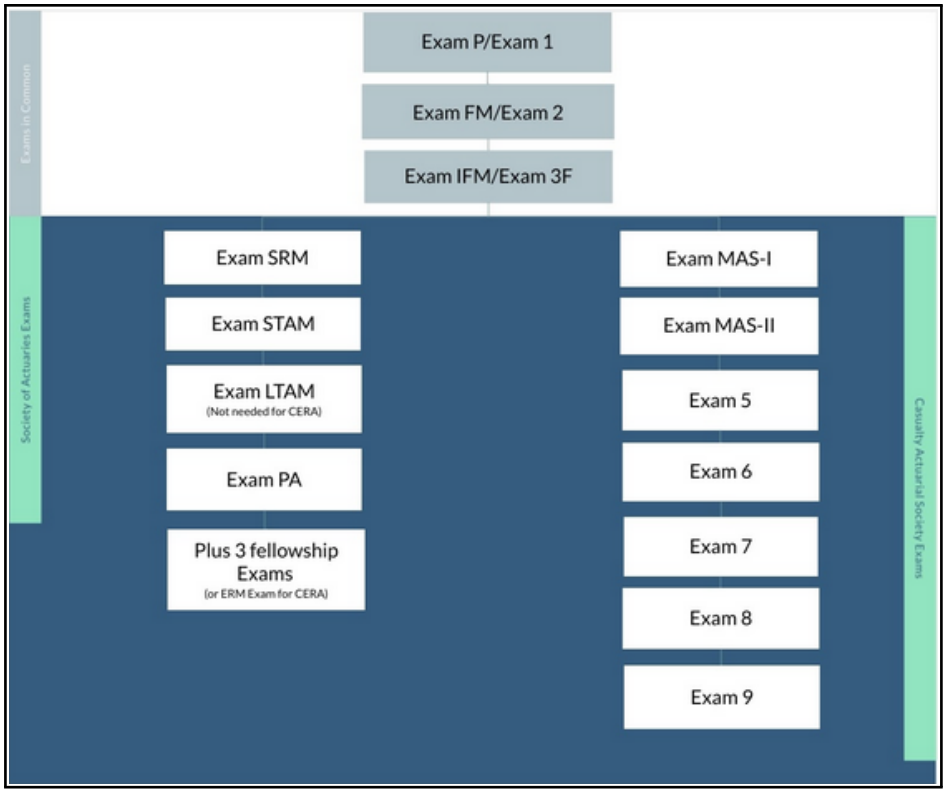

Fig. 4: *Actuary exams.*

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