# Mathematics at the Movies

## Exploring Linear, Quadratic, and Exponential Functions

**Amy Herman**
amyherman01@gmail.com

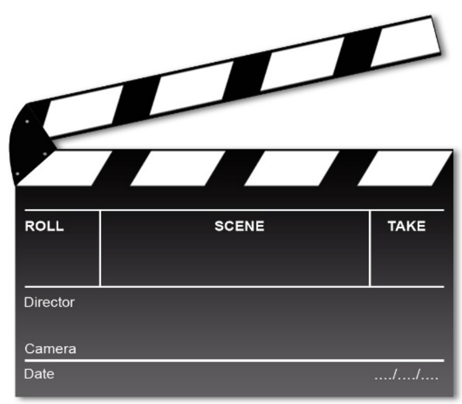
**Connie Horgan**
horganc@cableone.net

# The Top Money-Making Stars

The following are the top ten money-making movie stars.

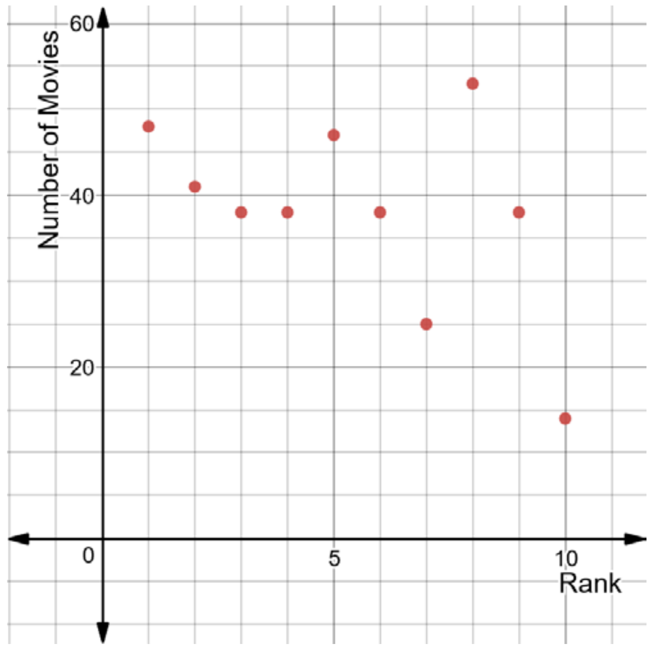
| Rank | Star | Number of Movies | Total Box Office Revenue |
|---|---|---|---|
| 1 | Tom Hanks | 48 | $4,523,833,325 |
| 2 | Robert Downey, Jr. | 41 | $3,859,852,419 |
| 3 | Harrison Ford | 38 | $3,728,200,434 |
| 4 | Eddie Murphy | 38 | $3,583,063,429 |
| 5 | Johnny Depp | 47 | $3,506,289,088 |
| 6 | Tom Cruise | 38 | $3,483,300,892 |
| 7 | Scarlett Johansson | 25 | $3,345,178,007 |
| 8 | Samuel L. Jackson | 53 | $3,235,478,338 |
| 9 | Matt Damon | 38 | $3,076,618,138 |
| 10 | Emma Watson | 14 | $2,938,245,314 |

(Source: https://www.the-numbers.com/movies/#tab=year)

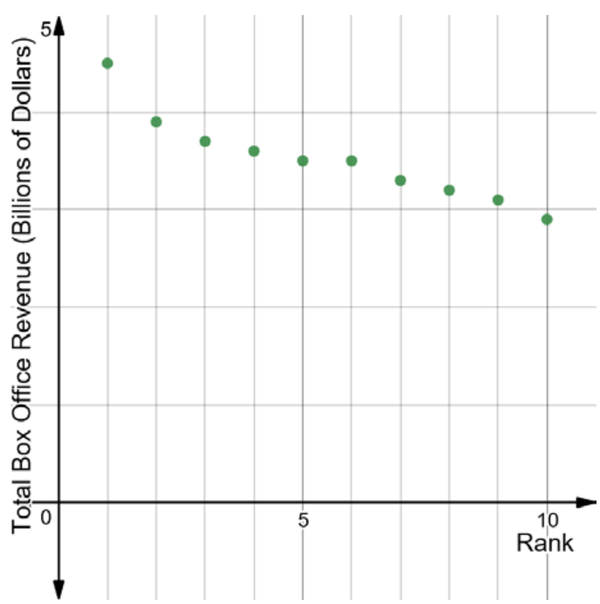


Do the following graphs seem to have a data trend? In each case, explain why a trend would or would not make sense based on the nature of the data.

Number of Movie Appearances of Top Ten Stars




Lifetime Earnings of Top Ten Stars



# The Top Money-Making Films

**The following are the top ten all-time money-making films.**

| Rank | Film | Year Released | Gross Domestic Box Office Receipts |
|---|---|---|---|
| 1 | Star Wars Ep. VII: The Force Awakens | 2015 | $936,662,225 |
| 2 | Avatar | 2009 | $760,507,625 |
| 3 | Black Panther | 2018 | |
| 4 | Titanic | 1997 | $659,363,944 |
| 5 | Jurassic World | 2015 | $652,270,625 |
| 6 | The Avengers | 2012 | $623,279,547 |
| 7 | Star Wars Ep. VIII: The Last Jedi | 2017 | $620,168,021 |
| 8 | The Dark Knight | 2008 | $533,345,358 |
| 9 | Rogue One: A Star Wars Story | 2016 | $532,177,324 |
| 10 | Beauty and the Beast | 2017 | $504,014,165 |

1. Graph the data using *Rank* as the independent variable and *Gross Receipts (in Millions of Dollars)* as the dependent variable.

2. Find the linear equation of best fit.

3. Find the exponential equation of best fit.

4. Which equation generates the graph of best fit? How do you know?

5. *A* quadratic equation seems to also have a good fit. Explain why a quadratic equation may not be appropriate for this type of data.

6. Use your equation of best fit to predict the Gross Domestic Box Office Receipts for *Black Panther*.

(Source: https://www.the-numbers.com/movies/#tab=year)

# Fountains of Bellagio

In the last scene of the movie *Oceans Eleven*, the main characters admire the fountains in front of the Bellagio Hotel in Las Vegas. When designing fountains, the contractors must consider the height and path of the water. In this activity, characteristics of the fountain will be analyzed.

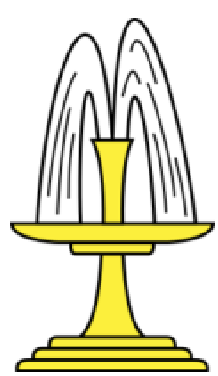
1. Select a photo of the one of the fountains of Bellagio. Lay the centimeter grid transparency over the fountain. Add x and y axes to your grid.

2. Draw 8 points along the path of the water from the fountain. Estimate the coordinates of each point.

3. Use the calculator and quadratic regression to get an equation that represents the path of the water. Let x represent the horizontal distance from the source of the water to the point on the path and y represent the height above the water to the point on the path.

4. Make a poster with an analysis of your quadratic function. Show a graph, table, and equation. Include mathematical and real-world information about intercepts, maximum/minimum, domain/range, etc. Show your work.

5. Compare your poster to those of other students. What are the similarities and differences? What caused those similarities and differences?



# Rising Costs of Movie Tickets

Inflation has influenced the cost of a movie ticket over the years. Complete the table below using the National Association of Theatre Owners website (http://www.natoonline.org/data/ticket-price/) or search for *NATO ticket prices.*

When completing the table, choose data from a variety of decades.

| **Years Since 1900** | **Average Cost of a Movie Ticket** |
|---|---|
| 0 | $.05 |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

a. Draw a graph of the data in the table below using *Years Since 1900* as the independent variable and *Average Cost of a Movie Ticket* as the dependent variable.

b. Use exponential regression to find the equation for the curve of best fit for the data. Describe the real-world meaning of each number in your equation.

c. Use the equation to predict the average cost of a movie in 2028. Discuss the reliability of this prediction. What factors could change the data trend?

# Popcorn

Movie concession stands used to sell popcorn, candy, and soft drinks. In recent years, concessions have expanded to include a wider variety of treats, including hot dogs, chicken sandwiches, and cappuccinos. Why? Theaters make more profit from concession items than admission tickets. Most of the money taken in at the box office goes to film distributors. Most of the concession stand profit goes back to the theater.

1. a. Use bags of popcorn cooked for the specified times to fill in the table below.

| **Number of Seconds Cooked** | **Number of Kernels Popped** | **Number of Kernels Not Popped** | **Total Number of Kernels Popped and Not Popped** | **Percent of Kernels Popped** |
|---|---|---|---|---|
| 0 | | | | |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | | | | |

b. Graph the data using *Number of Seconds Cooked* as the independent variable and *Percent of Kernels Popped* as the dependent variable.

c. Find an equation of best fit that can be used to represent the relationship between the cooking time and the percent of kernels popped.

d. Use your graph or equation to predict the percent of kernels popped if the popcorn is cooked 100 seconds.

e. Use your graph or equation to predict the percent of kernels popped if the popcorn is cooked 130 seconds.

2. The average American eats 58 quarts of popcorn a year.

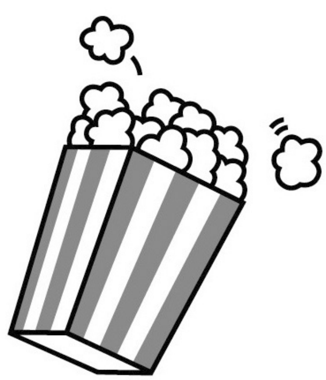
a. Write an equation that shows the relationship between the number of people eating popcorn (x) and the number of quarts (y) eaten in a year.

b. Graph your equation. Describe an appropriate window for your graph.

c. Use your equation to fill in the table below.

| Number of People Eating Popcorn | Number of Quarts Eaten |
|---|---|
| 100 | |
| 200 | |
| 300 | |
| 400 | |
| 500 | |
| 600 | |
| 700 | |
| 800 | |
| 900 | |
| 1000 | |

d. There are approximately 323 million people in the United States. Use your equation to find out how many quarts of popcorn are consumed by the people in the United States.



Sources: Wickipedia and www.seecalifornia.com

# The Shadow Effect

Years ago, special effects in movies were not as elaborate as they are now. Shadows were sometimes used to substitute for monsters and giants.

To create a large shadow, the film crew would create a small model of the character and shine a light on the model. The shadow would be projected on a wall, which would be filmed.

1. Suppose a stage light is set 4 feet from a $\frac{1}{2}$ foot model. The light is located 16 feet from the wall. Use triangles to draw a picture of this situation (side view). Label all measures.

2. Use properties of similar triangles to calculate how big the shadow will be in feet.

3. If the light remains 16 feet from the wall, how far away would the crew have to place the $\frac{1}{2}$ foot model to make an 8-foot shadow?

4. If the $\frac{1}{2}$ foot model is 4 feet from the light source, how far would the light have to be from the wall to make a 10-foot shadow?

Source: Encyclopedia Britannica

# Blocking the Scenery

When a film crew designs a set, they consider many factors, including how a prop may block the camera's view. To simulate this, try the following.

Use large grid paper with horizontal lines drawn at 0, 5, 10, 15, and 20 inches away from a fixed point.

1. Put the building on the horizontal line 10 inches from the fixed point and put the yardstick on the 20-inch line. The yardstick represents the backdrop on a set. The building is a prop.
   a. Look at the building from the fixed point. How much of the yardstick (in inches) cannot be seen? This is a model of a movie backdrop that is blocked by the building.
   b. Move the building to different locations on the same line. Does the length of blocked backdrop change? Use similar triangles and a drawing (top view) to explain why this happens.
2. Move the building to the line at 5 inches.
   a. Look at the building from the fixed point. How much of the yardstick (in inches) cannot be seen?
   b. Move the building to different locations on the same line. Does the length of blocked backdrop change? Use similar triangles and a drawing (top view) to explain why this happens.
   c. What is the ratio of the building's horizontal length to the length of the blocked part of the backdrop?
3. Assume the yardstick was put on a line 25 inches away and the building stayed on the line 5 inches away.
   a. How would the situation change? Draw a model.
   b. How much of the backdrop would be blocked?
   c. What is the ratio of the building's horizontal length to the length of the blocked part of the backdrop?

Cut out and use this building for the prop: