Name: KEY

Date: ____________

The Math Behind Epidemics – A Study of Exponents in Action

Many diseases can be transmitted from one person to another in various ways: airborne, touch, body fluids, blood only, etc.

How can math be used to try to model the spread of disease? If medical experts can figure out how a disease is being transmitted, and also have an idea of how fast it's transmitted, they can take the best steps to try to stem the outbreak.

We can model how fast epidemics spread using exponents!

PART A: For example, airborne diseases such as the flu (influenza) generally spread the fastest.

Let's take an extreme example: for every person who gets the flu, let's say they give one other person the flu each day. This is a 100% transmission rate (1 person gets infected from 1 person each day, so 1 ÷ 1 = 1 x 100% = 100% trans rate).

Day 0: Person A gets the flu

Day 1: Person A gets the flu, and gives the flu to Person B

Day 2: Person A gives the flu to Person C, Person B gives the flu to Person D

Day 3: Persons A, B, C, D each give the flu to one other person

and so on.... **This is a very simplified model of the situation*

1) Complete the Table:

Day	# with Flu
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512
10	1024
11	2048
12	4096

2) Build an exponential equation for the flu epidemic model using information from your table. A general exponential equation for epidemics is:

$$A = P(1 + \frac{transmission\ \%}{100})^t$$

A = number of people with disease

P = principal amount (number of people with disease on Day 0)

t= time (usually in days)

What is the equation for the flu model?

Build your equation here ⟶	$A = 1\left(1 + \frac{100}{100}\right)^t$
Final equation here ⟶	$A = 1(2)^t$

3) Test your equation by substituting:

a) Does your equation work for Day 5?

$A = 1(2)^5 = 1(32) = 32$ yes!

b) Does it work for Day 11?

$A = 1(2)^{11} = 1(2048) = 2048$ Yes!

4) Discuss and record below any limitations to the model developed. It is obviously a simplified model, so what are the problems associated with it? Sometimes, even though a model is simple, it may work well enough to be able to use to produce data that is 'close enough', so that medical experts can get a sense of the scale of the epidemic.

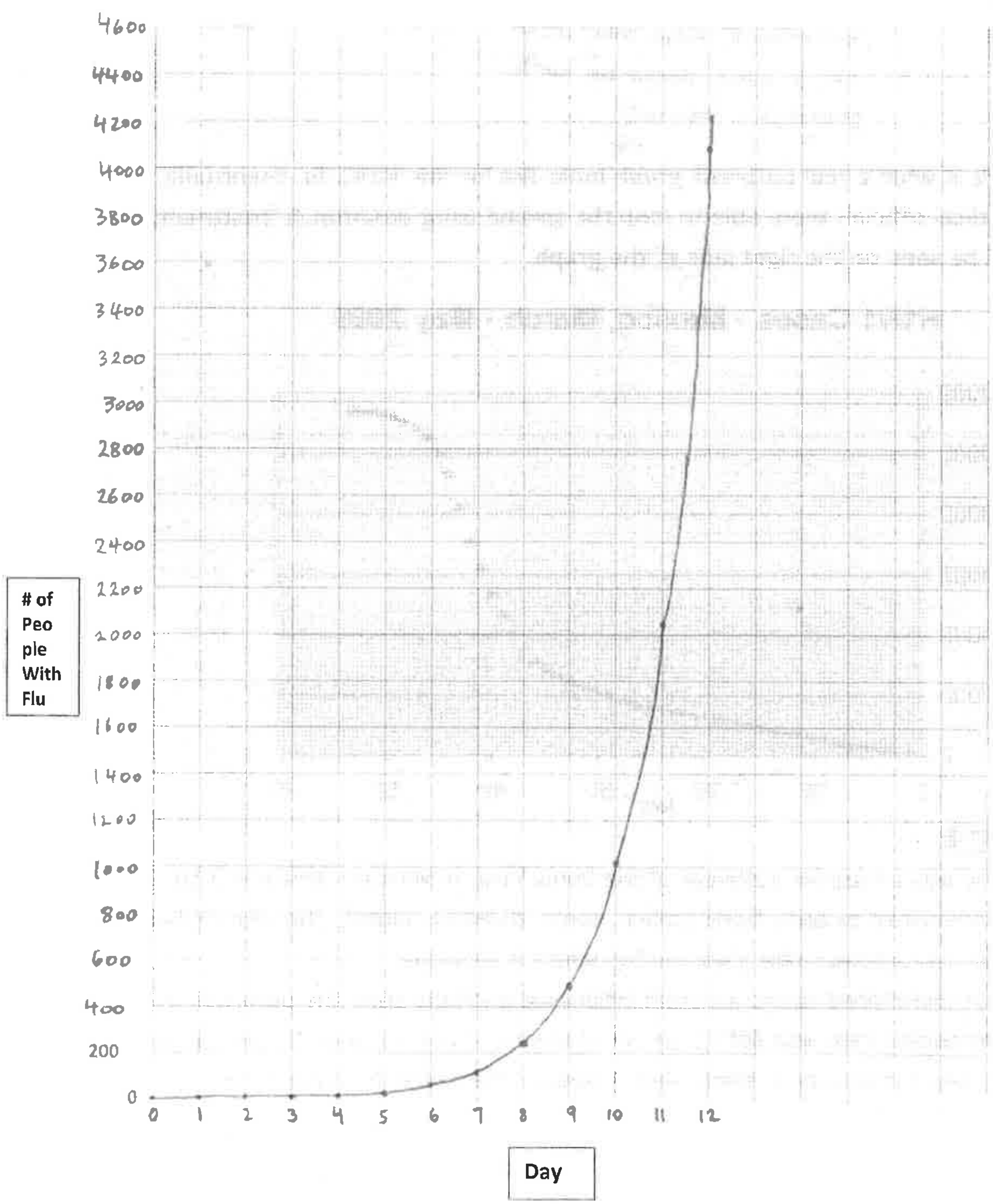
- people will recover in that time period
- transmission % may not stay constant
- people may die, so can't pass flu anymore
- vaccine may be released
- virus may mutate

etc.

5) Class discussion on limitations: be ready to share your ideas!

6) **Graph** on the grid provided using your table (by 1s for 'Day', by 200s for '# with flu').

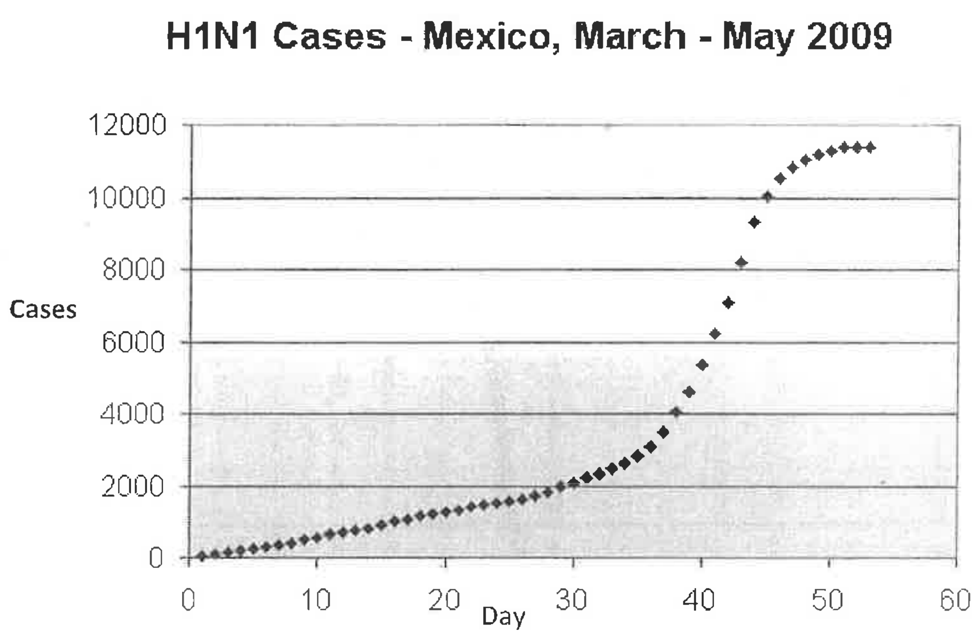
Flu Outbreak Graph



7) **The graph makes an 'EXPONENTIAL CURVE' (it increases very quickly!). Will the trend on the graph continue forever? Why or why not? Try to give sensible reasons.**

No b/c : - vaccines may be released
- mutation of virus may occur
- only so many people on earth
- geographic barriers
etc.

Here is what a real outbreak graph looks like for the H1N1 flu. Eventually, medical officials were able to stop the spread using isolation & treatment, as can be seen on the right side of the graph.



PART B:

There was a massive outbreak of the Ebola Virus in Western Africa in 2014. Ebola is transmitted by body fluids (saliva, vomit, diarrhea, blood), therefore it has a lower transmission rate than the flu, which is airborne.

Before developed countries could intervene and help stem the outbreak, the **transmission rate was 30%** (1 person transmits the disease to 0.3 people per day)

Let's say that on Day 0, there were 6 people infected with Ebola (P = 6)

1) Build an exponential equation for the Ebola Outbreak. $A = P(1 + \frac{trans\ \%}{100})^t$

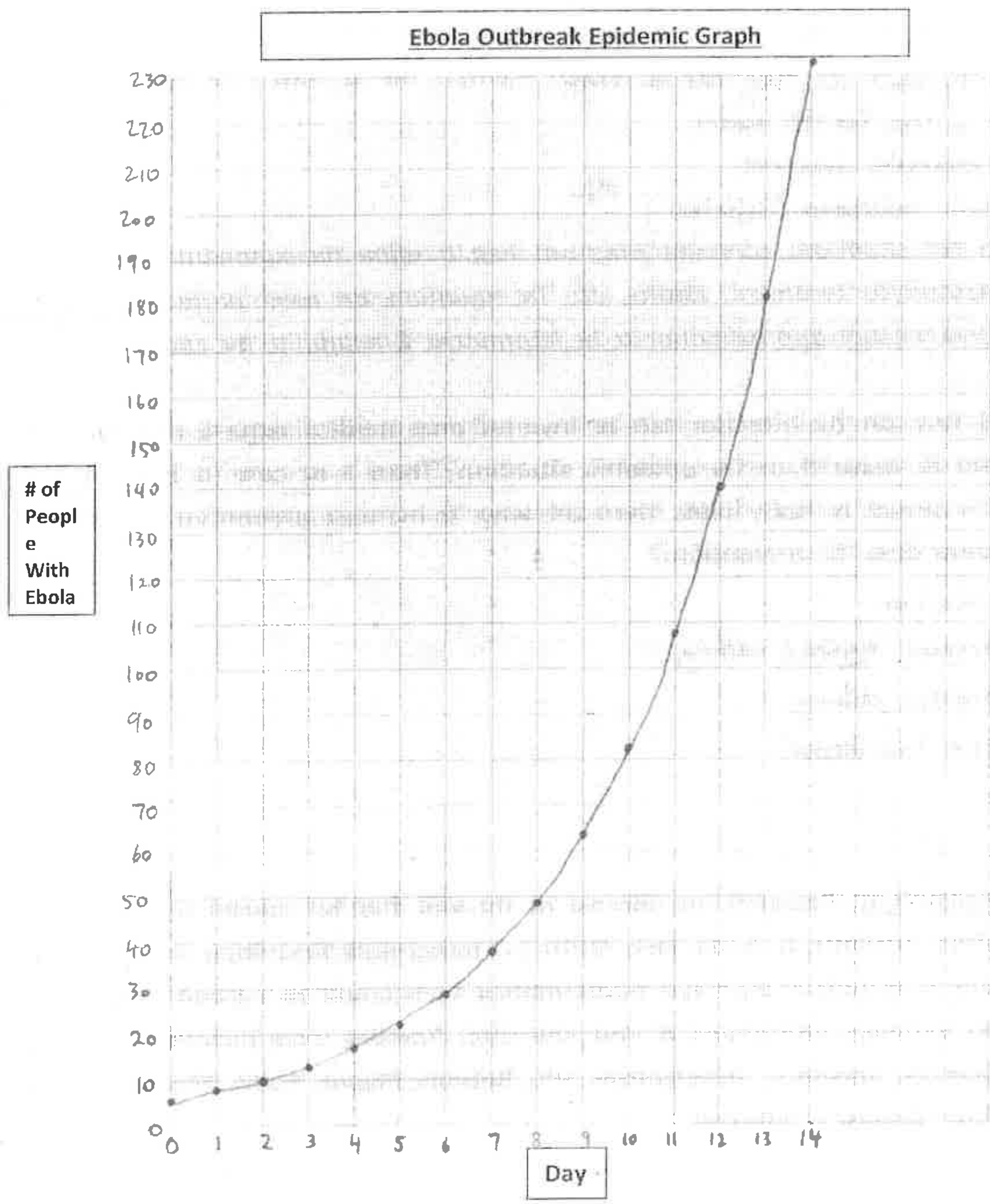
$$\boxed{A = 6\left(1 + \frac{30}{100}\right)^t}$$

$$A = 6(1.3)^t$$

2) Using your equation, complete the table:

Day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
# infected	6	8	10	13	17	22	29	38	49	64	83	108	140	182	236

3) Graph your data on the grid provided:



4) The fatality rate of Ebola is 50%, meaning half the people who get Ebola will eventually die. Using your results, how many people who contracted Ebola in the first 14 days will eventually die?

$236 \div 2 = 118$

5) What are the limitations of the model we just used for Ebola? Think about the previous question when pondering the limitations.

- If people die, they can no longer transmit the disease, so the numbers will be lower than the model.
- geographic boundaries
- aid + medication / isolation

etc.

In real situations, computer programs help to refine the exponential equations to account for treatment, deaths, etc. The equations are never perfect, but can be a good enough approximation to be informative & helpful to the cause.

6) How can the infection rate be lowered once medical experts are aware of, and do research on the epidemic situation? There is no cure for Ebola, but since it is spread by body fluids, there are ways to increase prevention. What are some ideas for prevention?

- isolation
- frequent hygiene / washing
- disposable clothing
- proper fluid disposal

<u>Assignment</u>: Research one disease on the web that has caused an epidemic either currently or in the past. Write 1-2 paragraphs describing the epidemic. Be sure to include at least two mathematical facts (could be a graph included). Give the webpage address(es) of your source(s). Possible ideas include: Malaria, Measles, Smallpox, Tuberculosis, HIV, Bubonic Plague, H1N1, Mumps, or any other disease of interest.