

AP Quiz 1: Mathematical Tools

Your name-period here:

1 Analyze this, dimensionally

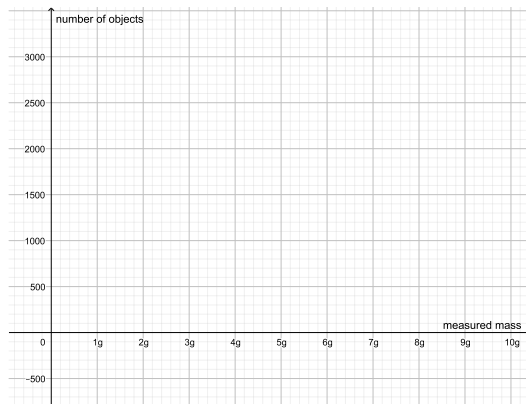
When massive particles gather together into large objects, they have a quantity called binding energy that determines how hard the object would be to pull apart. It is reasonable to assume that the binding energy E ($[E] = \text{J}$) might depend on the total amount of mass M ($[M] = \text{kg}$), the size of the sphere R ($[R] = \text{m}$), and the gravitational constant G ($[G] = \frac{\text{Nm}^2}{\text{kg}^2}$).

1. (4 pt) Use dimensional analysis to find an approximate formula for E in terms of the other variables given.
2. (1 pt) Evaluate your expression for the sun, which has radius $7 \times 10^5 \text{ km}$ and total mass $2 \times 10^{30} \text{ kg}$. The numerical value of the gravitational constant in SI units is about $G = 7 \times 10^{-11} \frac{\text{Nm}^2}{\text{kg}^2}$.

2 An error walked into a bar...

You are attempting to measure grains of sand with mass of exactly .001 g each using a scale that can only read out in 1 g increments (eg it can display either 1 g or 2 g, but not 1.5 g), but is perfectly accurate and rounds correctly.

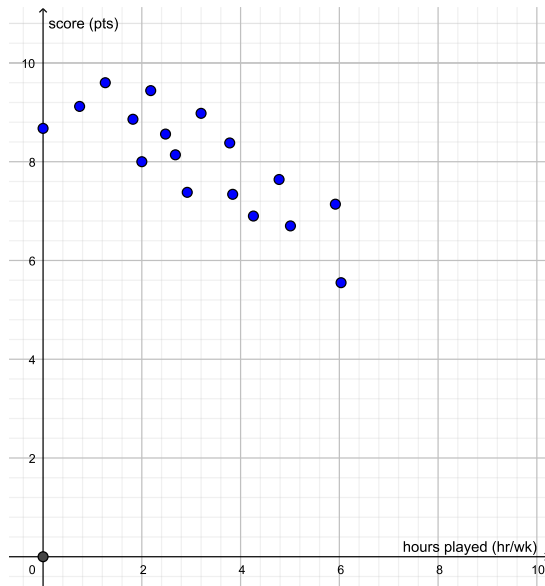
1. (5 pt) Draw the graph of the actual number of grains on the scale as a function of the measured mass.



(0 pt) Does your name appear at the top of the paper? If not, explain why in the form of a haiku that includes your name and the word “pickle.”

3 An unfortunate trend

Below is an (entirely made up) graph relating number of hours spent per week playing fortnite and the student's score out of 10 points on an assessment. The points are free of error.



1. (2.5 pt) Plot the trend line
2. (2.5 pt) Determine the expected number of hours that a student spent playing fortnite in a week if there score on the exam was 20% and comment on whether this extrapolation was reasonable in a real dataset.

4 Never let a physicist draw your treasure map

Below are the directions a new friend gave you to find a certain point in an empty field.

First walk $\vec{q} = -2\hat{x} - \hat{y}$

From there, walk $\vec{s} = \hat{x} - 3\hat{y}$

From there, walk $\vec{u} = \hat{x} + 2\hat{y}$

Finally walk $\vec{w} = 3\hat{x} + \hat{y}$

1. (2.5 pt) Write the displacement to that point as a vector in terms of $\hat{x}$ and $\hat{y}$.
2. (2.5 pt) What was the total distance traveled? You may leave your answer in terms of square roots.