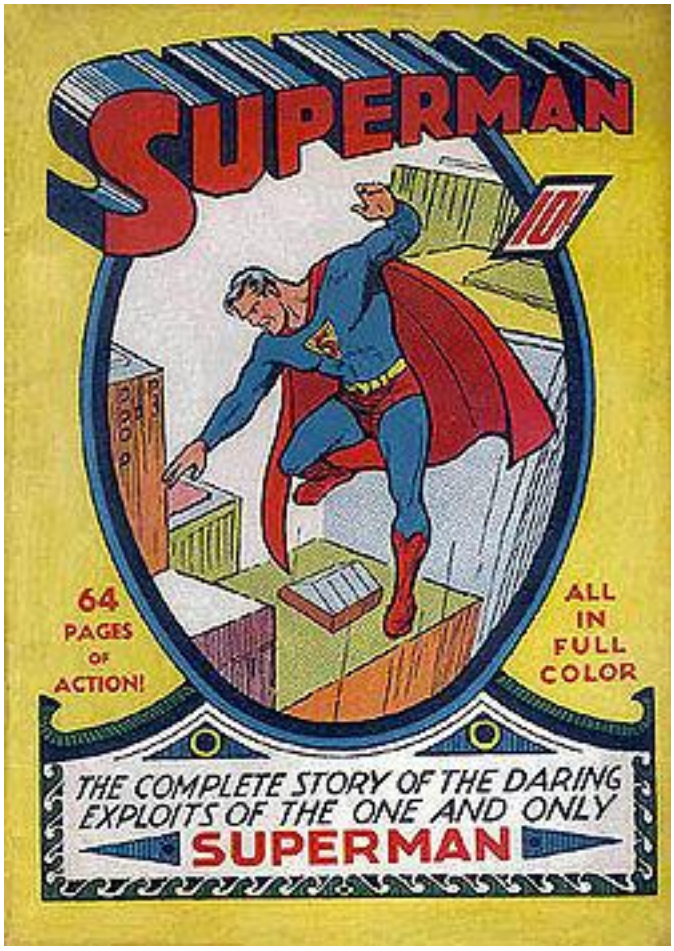
Superman Lab

Introduction:

In the original Superman Comic (#1) , the 100kg Superman can only jump to a height of 600ft (201 m).

This capability was due to the fact that he was born on the planet Kyrpton, and this planet has a stronger gravitational field. The purpose of this lab is to answer the questions: "What is the value of ***g***, the acceleration due to gravity, on ***Kyrpton***, and how must stronger is this than that on Earth?"



Superman's' arch enemy, ***Lex Luther*** has done some calculations himself to determine the answer to those questions. The purpose of this lab is for you to compare your results with that of ***Lex***. Also, investigate if the logic ***Lex*** used was valid.

Lex Luther's Concepts in the Determination of Gravitation Acceleration Factor g

When you (or Superman) jump up, you start with an initial velocity, v_i , and when you (he) reaches the maximum height, your (his) final velocity, v_f , is zero, then you start falling back down to the Earth

Other Questions for you to Answer :

If we measure how high an average human can jump straight up. Then compare that (as a ratio) with how high Superman could jump, would this give us the answer we are looking for? Or, is it more complicated than that and we have to follow ***Lex Luther's*** technique?

Your Teams's Task:

Set up an experiment that will measure how high the average member of your group can jump. You should plan out this task and do not be afraid to incorporate any technology that you think will provide you with answer you are looking for.

Recommended tools: Metre sticks (will be provided)
Recording device (Smart Phone)
Stop watch
Bathroom scale

Note: You will need to apply proper mathematical techniques to determine the final answer with the correct errors (confidence factor).

Lex's Algebraic Approach to Determine to the Problem of Superman on Earth

Lex wanted to first determine the velocity he leaves the ground with when Superman leaps into the sky. He relies on his knowledge of Kinematics or Gravitational Energy conservation to determine this velocity.

Kinematics

$$v_f^2 = v_i^2 + 2ad$$

$$\left(0\frac{m}{s}\right)^2 = v_i^2 + 2\left(-9.8\frac{m}{s^2}\right)(201m)$$

$$v_i^2 = 3939.6\frac{m^2}{s^2}$$

$$v_i = 62.77\frac{m}{s}$$

Energies

$$E_i = E_f$$

$$K_i + U_i = K_f + U_f$$

$$\frac{1}{2}mv_i^2 + 0 = 0 + mgh$$

$$v_i^2 = 2gh$$

$$v_i = \sqrt{2gh}$$

$$= \sqrt{(2)\left(9.8\frac{m}{s^2}\right)(201m)}$$

$$= 62.77\frac{m}{s}$$

To achieve this value of $62.77\frac{m}{s}$ Superman has to crouch down then he pushes up with his legs. This requires a Force by his legs.

Lex used $F = ma$ to calculate this force.

He knew that m=100kg for Superman, he needed to determine the acceleration, a

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t}$$

Lex watched Superman You Tube broadcasts and found that Superman took about a quarter of a second to move from a crouch to an extended position

You will need to determine this value for your average group member

Thus Lex determines the acceleration of Superman as: $a = \frac{62.77\frac{m}{s}}{0.25s} = 251.08\frac{m}{s^2}$

Lex required the Force Superman's legs pressed against the ground during the jump process

Therefore the Force that Superman applies is: $F = ma$

$$= (100kg)\left(251.08\frac{m}{s^2}\right)$$

$$= 25108N$$

Lex determined the acceleration due to gravity by applying, $W = mg$, where *W* represents the weight that would be measured on a weight scale if Superman was standing on a scale when we jumped into the air.

Lex was careful though. He knew that there is a value of *W*, as measured on the scale, just by Superman standing on the scale. He needed to determine the value of *W* that excludes that normal weight of Superman standing on the scale.

Lex Luther estimates that the force exerted by Superman is 70% larger than the force on his legs while standing still.

Thus: $25108N = (1.7)W_{Krypton}$

$$W_{Krypton} = 14,769N$$

Therefore Superman weights 14,769N on the planet Krypton

Lex now used: $W_{Krypton} = mg_{Krypton}$

$$14,769N = (100kg)\, g_{Krypton}$$

$$g_{Krypton} = 147.69\frac{m}{s^2}$$

then using $g_{Earth} = 9.8\frac{m}{s^2}$, Lex then determine the ratio of $\frac{g_{Krypton}}{g_{Earth}} = \frac{147.69\frac{m}{s^2}}{9.8\frac{m}{s^2}} = 15.07$

Therefore ***Lex*** determined that the planet Krypton has about 15 times the strength of gravity than on Earth.

Questions to answer on you lab

1) What was the v_i for your group? Compare that with $v_i = 62.77\frac{m}{s}$ **Lex** calculated for Superman.

   Remember you will be averaging all the velocities of your group members (I recommend each member jumps 3 times, so that you have at least 10 velocities to compute the average v_i along with its error for your group.

2) What was the a of your group when jumping up. Compare that with the $a = 251\frac{m}{s^2}$ that **Lex** calculated for Superman.

   Remember you will be averaging all the accelerations of your group members (see Question 1 for the data in determining the acceleration for each jump of your group.

3) How accurate was **Lex's** 70% estimate for Extra Force over the standing force. What did your group determine was the extra force percentage over the standing force?

4) What did you determine as the value for g_{Earth}.
   *You will be following **Lex's** technique, but rather that the $g_{Krypton}$ being determined, your value for a hypothetical 100kg person will be g_{Earth}.*

5) Compare this value with the know value of $g = 9.8\frac{m}{s^2}$

6) What did you determine as the value of by how much is Krypton's gravity is stronger than Earth's?

   That is, compare the ratio of accelerations from Question 2)

7) Could you have determined the answer faster than the method used by **Lex**? If so how

Remember, the answers that you obtain are only part of the marks for the Lab, I will also be looking at your error analysis calculations. So use the Error analysis notes I have provided for you to assist in the calculations. In your lab Log book (Journal), you should create a table that contains the following data requirement headings. This table would then also appear in your Lab Report.

I would recommend that you also have heading in which you can calculate other values from the data collected. This way you can immediately check the validity of you collected data.

Entry Number	Maximum Height $h\left(\frac{m}{s}\right)$	Duration of push $t\,(s)$	Maximum Value on Scale $W(kg)$
1			
2			
⋮			