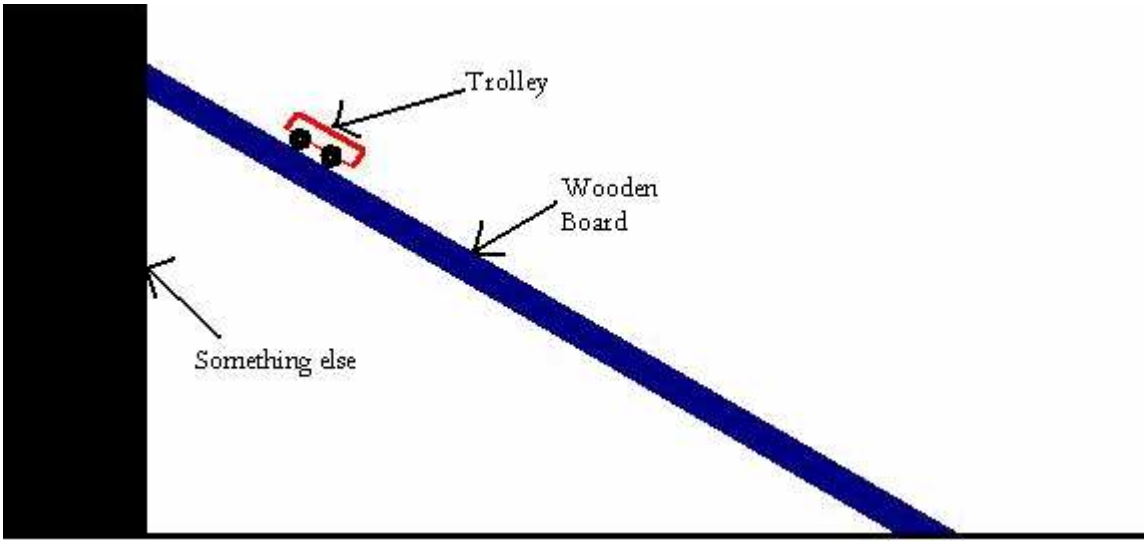
TROLLEY INVESTIGATION

Introduction:
This is an investigation on the acceleration of a wheeled object going across an angled ramp. To clarify; we need to see if the angle effects this acceleration. In this case the object is a wooden trolley and the ramp is a flat straight wooden board. This can be observed in the diagram.



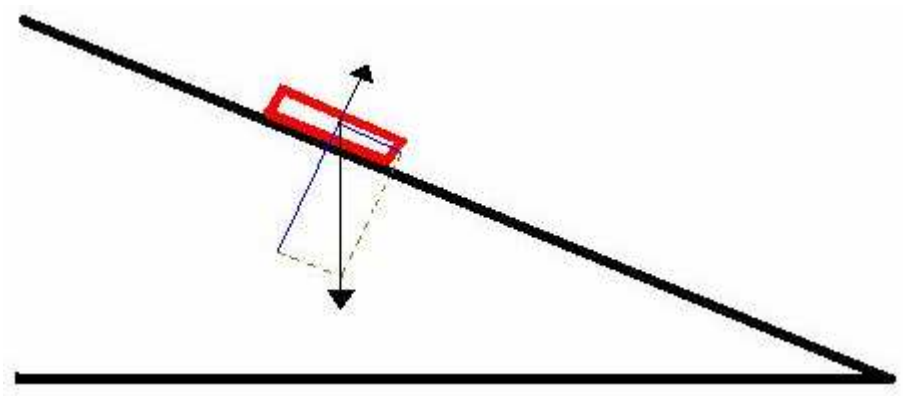
Aim:
To find out whether or not the angle of the ramp affects the acceleration of the trolley.

Prediction:
I predict that on a steeper ramp the trolley will accelerate faster; meaning the angle of the ramp is directly proportional to the acceleration.

Hypothesis:
Our Earth has a gravitational pull which gets weaker the further away an objects gets from it; and stronger the closer it gets; hence the closer the object is to the earth then the stronger gravitational force will be acting upon it from the earth. I have made my prediction to be what it is based on my previous knowledge and what I have learned from my science classes and textbooks. I think that a steeper ramp angle will cause the trolley to accelerate faster; this is because we are measuring the time it takes for the trolley to get to the bottom of the ramp; and the changes in acceleration. Every 2 dimensional movement (ignoring the fact the trolley can go side to side) has 2 directions: X and Y. In this experiment Y will be gravity and X will be determined by the angle of the ramp. If the ramp is steeper than the net movement of the trolley will be forwards and downwards; and as the ramp will be steeper this will allow the Y force of gravity to pull the object quicker; as the area of the ramp will be cleared in a quicker time.

I have also noticed that the mass of the object does not effect the acceleration; this is because if an object has a higher mass then gravity will need more force to pull it whilst an object with a lower mass will need less for to be pulled; hence they are both pulled with the same speed/acceleration ratio to earth (disregarding other factors such s aerodynamics).

I will be employing the use of mathematical equations to help me with my experiments. The mathematical techniques I will be using are trigonometric techniques as detailed in my Maths classes.



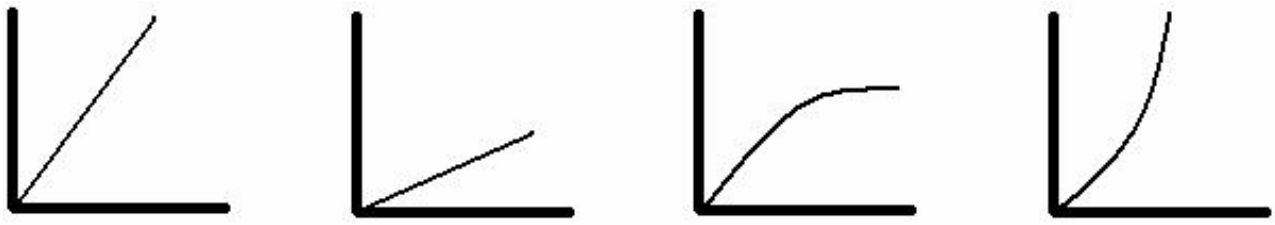
The mathematical techniques we will be using were derived from a mathematician called Pythagoras. In these works; angles and sides can be determined for other data in triangles. In this experiment; the ramp; its height and the floor form the 3 sides of this triangle; so we can use this data to calculate the angle of the ramp.

Key:

m = mass
g = gravity
a = acceleration
F = force
w = weight of gravity
$\wp$ = air resistance

The equation to be used for the formula is $\mathbf{F\chi = w \times \sin\theta}$, as I am aware that **f=ma** is the same as $\mathbf{f=ma\chi}$. I was also taught that $\mathbf{f\chi=wxsin\theta}$, which can be written as $\mathbf{ma\chi=wxsin\theta}$ as the values are the same and basic substitution has taken place. And since **w=mg,** this can be added to the equation; thus making it $\mathbf{ma\chi=wxsin\theta}$, and we can then change it to $\mathbf{mg\chi=mgxsin\theta}$, and as mass is in both sides of the equation; it can be cancelled out as nothing new results from it; thus making the equation for acceleration: $\mathbf{a\chi=gxsin\theta}$.

This equation can be considered perfect if it were not for 2 factors: Friction and Air Resistance. As these 2 factors will effect the acceleration; I will have to add an equation to remove the results of friction; the equation I will need to add is $\mathbf{a\chi=gxsin\theta - \wp}$**.** We will not be calculating the results of friction in this experiment; but I have predicted the results if we did in the following graphs:



1. 2. 3. 4.

1. No Friction
2. With Friction
3. Steep Angle/Low Friction
4. Steep Angle/High Friction

Equipment:
Trolley; Ramp; Ticker Timer; Ticker Tape; PowerPack; Leads; Power Outlet; Measuring Tape; and some sort of weak adhesive (Blue Tack / sellotape will be fine).

All the same apparatus will be used throughout the experiment; bar the Ticker Tape as it cannot be reused; this is to ensure all conditions are the same all the way through the experiment. All the apparatus should be independently tested to ensure accuracy and good working order.

Method:
To test this experiment; we will need to ensure that our results are accurate and everything is as fair as possible. To ensure fair testing to prevent inaccurate results; the following measures will be taken:

The position of the trolley will be checked to make sure it is level and it is starting from the exact top of the ramp.

When the trolley is at the top of the ramp waiting to be released; it will be released without applying any force. This is so that the trolley moves from a stop instead of being pushed by a scientist.

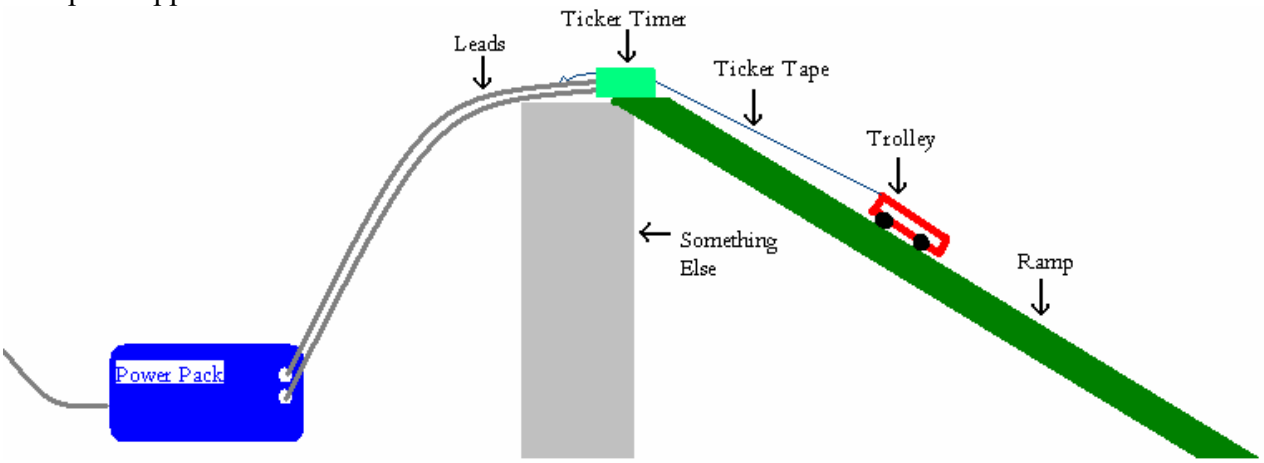
The timing will only be stopped once all the wheels of the trolley are on the ground and before it starts rolling off down the laboratory. This is to ensure only the results for the ramp are recorded.

Throughout the length of this investigation ticker timers were used. A ticker timer "ticks" onto special tape 50 times a second; and this tape leaves a mark when struck; hence there will be 50 marks per second on to the tape. To measure the speed/acceleration of an object; the ticker tape is fed through the ticker timer and stuck to the object. As the object moves it pulls the ticker taper through the ticker timer thus making dots on the tape. The distance between these dots can be measured to work out the speed and acceleration of the moving object. As the object travels faster

the gaps between the dots on the tape increase; this allows one to measure the acceleration/speed of the object at that moment in time.

Here are the steps to this investigation:

Set up the apparatus as shown:



1. Connect the PowerPack to the mains outlet and connect 2 leads to it and the ticker timer.
2. Feed some ticker tape into the ticker timer. The tape should be a little more than the length of the ramp.
3. Stick the ticker tape to the trolley using a weak adhesive.
4. Make sure everything is set out like it is on the diagram.
5. Use the trigonometry techniques to find out the angle of the ramp at specific heights.
6. Measure the height of the ramp using the measuring tape and ensure it is accurately positioned.
7. Start the PowerPack and ensure that the ticker timer is running.
8. Ensure the ramp is clear of all obstructions and it does not have anything on it (such as wet or having dust on it).
9. Hold the trolley at the top of the ramp and simply release it; do not push!
10. Once the trolley has reached the bottom of the ramp stop the ticker timer and remove the ticker tape. Store the ticker tape for analysis and use new ticker tape for more angles.
11. Ensure everything but the main variable (the height of the ramp) is the same.

Analysis/Calculations

1. First cut the used ticker tape/mark it into 11 dot sections. Marking is recommended to cutting to prevent loss of sections. Remember that each of these sections would equal 0.2 seconds.

2. Now measure the first 11 dot sections with the measuring tape and note down the measurement. Label this as **d1**.

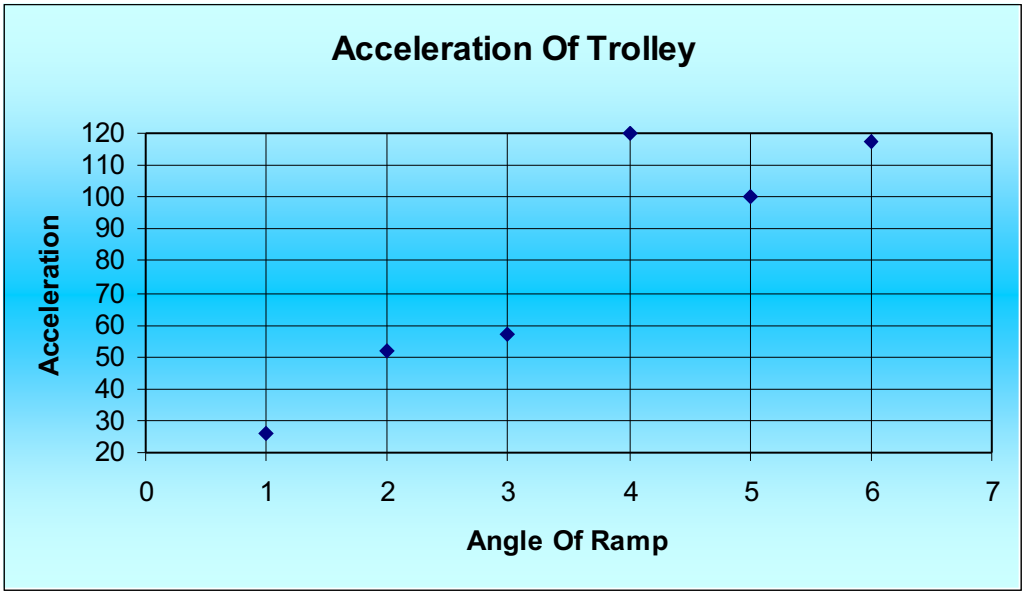
3. Now measure the last 11 dot section with the measuring tape and note down the measurement. Label this as **d2.**

4. Now that we have **d1** and **d2**; we can move on and find out **v1** and **v2**. In order to do this we need to divide **d1** over 0.2 and **d2** over 0.2; as 11 dots are equivalent to one-fifth of a second; hence he divide it by 0.2. (0.2 and one-fifth (1/5) is the same.)

5. To calculate the acceleration I will employ the use of the following formula: **v2-v1**. The resulting answer is the acceleration of the trolley.

Results Table:

Angle of ramp (°)	d1 (mm)	t1 (sec)	v1	d2	t2	v2	Acceleration
10	90	0.2	4.5	193	0.2	9.65	25.75
20	190	0.2	9.5	420	0.2	21	51.5
30	255	0.2	12.75	460	0.2	23	57.25
40	190	0.2	9.5	670	0.2	33.5	120
50	175	0.2	8.75	575	0.2	28.75	100
60	300	0.2	15	770	0.2	33.5	117.5



Conclusion:

The line of best fit shows that my prediction was correct; meaning that a steeper angled ramp results in a faster acceleration of the trolley. My prediction was correct; this is because once the angle of the ramp increases the trolley is being pulled faster down to the ground by gravity and the ramp's horizontal co-efficient decreases. Simply; if the ramp is steeper; then the trolley will still be pulled down it; but as it cannot go through the ramp it will have to go down it. So if the ramp is steeper then the trolley will get down faster as it will use most of its potential energy going downwards instead of going forwards down the ramp.

Evaluation:

I think this experiment went along really well and the results were reliable; bar the anomaly. I think that my predictions were good from my previous knowledge and my hypothesis was improved upon after I did the experiment. I have learnt much more about this topic than I thought I would and it was academically rewarding.

There were 2 anomalies; one major anomaly and one minor anomaly. The major anomaly was recorded at 40°; whilst the minor one was recorded at 20°. The major anomaly at 40° was 40 units from the expected value. This could have possibly been because the calculations were misread by someone or perhaps the data was input incorrectly into the calculators. If we had a larger timescale we would have repeated these anomalous results in the same conditions to ensure a fair test. I think the main problem here was the factor of human error. This problem can be prevented in the future by having someone to continuously supervise the experiment and its necessary steps to ensure that these problems do not happen. I think the results were reliable none-the-less if the anomalies were ignored and a line of best fit was drawn on the graph. If I look back on my predictions and my hypothesis then I think I can safely say I was pretty much on the right track and I had correctly made my predictions.

There were some problems and I have ideas on how they can be improved. A problem was that the ticker timer and the ticker tape were causing a frictional effect on the trolley. This problem can be solved with the aid of light gates as these are newer; more accurate and easier to read. Another problem was the scope of my investigation; as I could have tested out more angles.

I think that a further investigation to prove that mass don't not affect the rate of acceleration should be taken out. In this experiment a small amount of weights will be added to the trolley each time; but in this case the angle will remain the same all the way through but the weights will change.

Mini-Plan:

Aim:
To find out whether mass affects the acceleration of an object travelling down a ramp.

Prediction: I am certain that the added mass will not affect the acceleration of the trolley.

Hypothesis:

I think this is because if an object is heavier then gravity will need to pull harder on the object to pull it down; but it will still reach the ground at the same time compared to another object of a different mass.

I also know this by referring to text books and reading about a famous previous experiment was carried out where 2 bags were dropped from a tower. One bag was full of feathers whilst the other was full of bricks. Both reached the ground at the same time. I know this is the same principle that will be applied in this experiment.

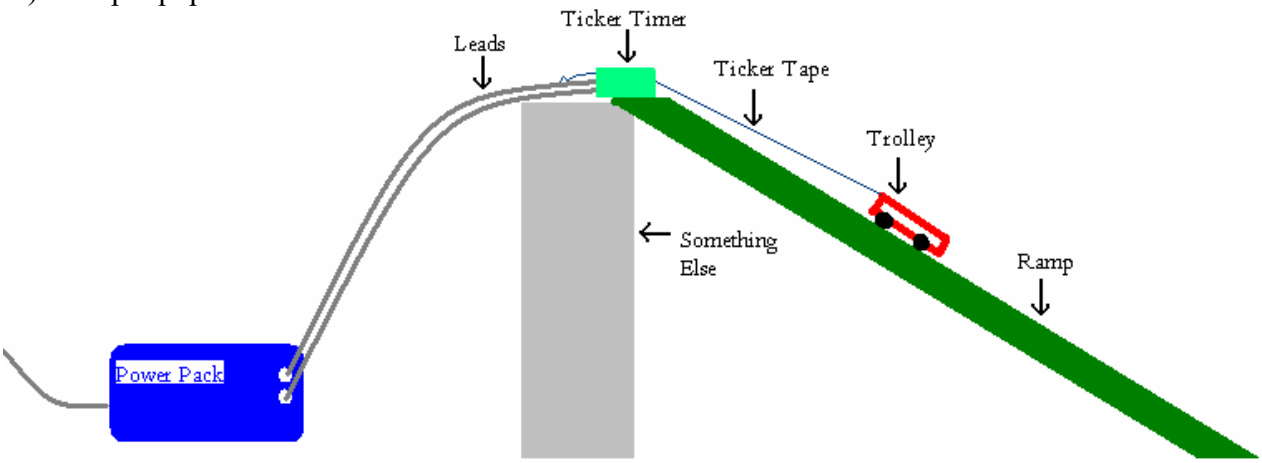
I can also prove this mathematically because in my previous hypothesis the mass was cancelled out, hence it does not play a part in the experiment:

Fχ **= w x sin**θ, I already know that **f=ma;** which is equivalent to **f=ma**χ. I am also aware that **f**χ**=wxsin**θ, thus meaning **ma**χ**=wxsin**θ. And since **w=mg,** this can be substituted into this equation: **ma**χ**=wxsin**θ, which then changes into **mg**χ**=mgxsin**θ, as mass is on both sides of the equation; it might as well not be there; so it is cancelled out. This leave me with the equation for acceleration: **a**χ**=gxsin**θ.

Method:

The method in this experiment is the same as the one used previously:

1.) Set up equipment as before:



2.) Feed some ticker tape into the ticker timer; ensure that there is a bit more than the length of the ramp.

3.) Connect the PowerPack to the mains outlet and to the ticker timer.

4.) Ensure that everything is the same as before; except the main variable (in this case it's the extra weights added to the trolley instead of the change of ramp angle)