Practical-2

Projectile motion in two dimensions

Name- Satvik Sharma

Student ID -218595095

Unit- engineering physics

Unit code -SEB101

Group members- Zac Brydon

Chris Jones

Jude Zhu

Session Date- 12/04/2019

Submission Date- 19/04/2019

Reports

Aim

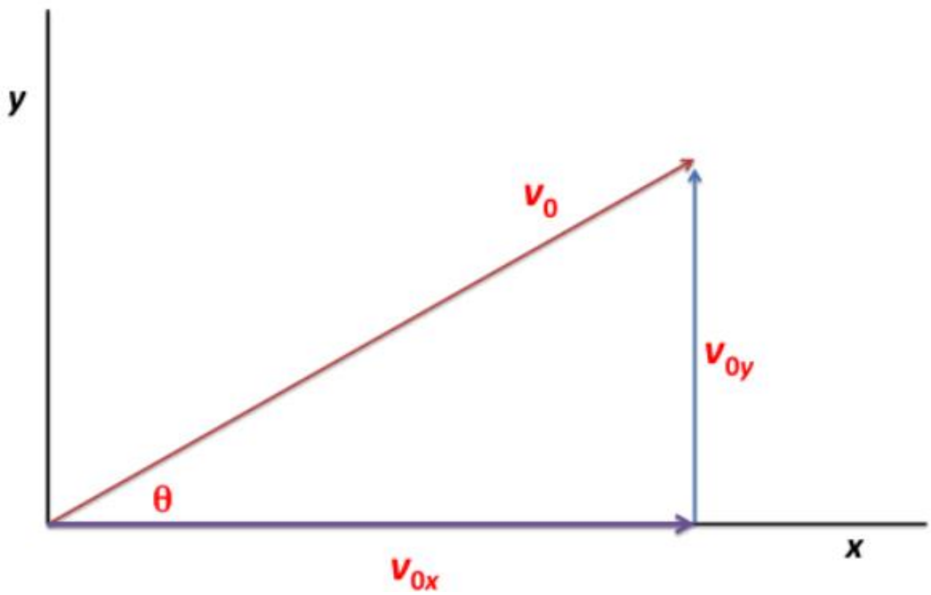
The agenda of this experiment is to study the projectile motion in two dimensions. Further investigating the muzzle speed of the spring-loaded gun and verifying the kinematics equations associated with it. Also finding the angle at which the range or distance covered by the ball is maximum.

Introduction

A particle which is thrown near the surface of earth and moves in a curved path under the action of gravity is defined as the projectile motion and the object is called projectile. Let the velocity with which the projectile is thrown be v_0 at angle θ with the horizontal. The component along the x axis and y axis are given and depicted below.

$v_{0x}=v_0\text{Cos}\theta$

$v_{0y}=v_0\text{Sin}\theta$



If the ball is launched at angle θ, the distance it covers in the horizontal direction is given by

$x=v_{0x}t$

$=(v_0\text{Cos}\theta)t$ ...(i)

And if the ball is launched at height y_0 and goes up to the height y, the displacement is given by

$y=y_0+v_0\text{Sin}\theta-1/2gt^2$

time can be predicted assuming the velocity at the peak is 0

this means that $v_y=0$

or

$v_0\text{Sin}\theta-gt=0$

$t=v_0\text{Sin}\theta/g$

this is the time taken to reach the maximum height. For the total time taken, it must be twice the time taken to reach the maximum height

i.e. total $t=2v_0\text{Sin}\theta/g$ ...(ii)

furthermore using (i) and (ii),

$x=(v_0\text{Cos}\theta)t$

or

$=(v_0\text{Cos}\theta)(2v_0\text{Sin}\theta/g)$

$=v_0^2(2\text{Cos}\theta\text{Sin}\theta)/g$

$=v_0^2 Sin2\theta/g$ ...(iii)

This is the formula for range travelled by the ball.

Experiment method

Part-A: Measuring the muzzle speed

1. Insert the ball into mini launcher for the angles given
   a. 20^0
   b. 40^0
   c. 45^0
   d. 60^0
   e. 80^0
2. Launch the ball each for the long, medium and short ranges at least three times and take average along with uncertainty.
3. Take the readings with the help of photogate
4. With the change in inclination, it will be investigated if the muzzle speed changes.

Part-B: Projectile range vs the angle of inclination

1. Clamp the launcher with the side of table and adjust the following angles
   a. 10^0
   b. 20^0
   c. 30^0
   d. 40^0
   e.45^0
   f. 50^0
   g. 60^0
   h. 70^0
   i. 80^0
2. Launch the ball in medium position with each angle to find where the ball lands
3. Mark the position at which the ball lands and place a graph paper and carbon paper on it, so that the ball marks the position every time it lands.
4. With every angle, launch the ball at least four times.
5. Measure the distance with every launch. Find its mean and uncertainty.

Results and calculations

Part: A

1. 20 degrees

Run	Range type	Time between photogates	Velocity(m/s)	Average velocity	Uncertainty in velocity
1	Short range	0.034264	2.92	2.91	0.01
2		0.034275	2.92		
3		0.034367	2.91		
4		0.034660	2.89		
1	Medium range	0.025957	3.85	3.87	0.01
2		0.025795	3.88		
3		0.025806	3.88		
4		0.026123	3.87		
1	Long range	0.019403	5.15	5.15	0.00
2		0.019404	5.15		
3		0.019417	5.15		
4		0.019394	5.15		

2. 40 degrees

Run	Range type	Time between photogates	Velocity(m/s)	Average velocity	Uncertainty in velocity
1	Short range	0.035362	2.83	2.82	0.005
2		0.035286	2.83		
3		0.035339	2.83		
4		0.035477	2.82		
1	Medium range	0.026214	3.83	3.82	0.005
2		0.026098	3.83		
3		0.026119	3.83		
4		0.026207	3.82		
1	Long range	0.019574	5.11	5.11	0.01
2		0.019493	5.13		
3		0.019531	5.12		
4		0.019585	5.11		

3. 45 degrees

Run	Range type	Time between photogates	Velocity(m/s)	Average velocity	Uncertainty in velocity
1	Short range	0.035486	2.82	2.80	0.015
2		0.035851	2.79		

3		0.035683	2.80		
4		0.035583	2.81		
1	Medium range	0.026119	3.83	3.83	0.005
2		0.026100	3.83		
3		0.026062	3.84		
4		0.026054	3.84		
1	Long range	0.019509	5.13	5.11	0.015
2		0.019604	5.10		
3		0.019592	5.10		
4		0.019585	5.11		

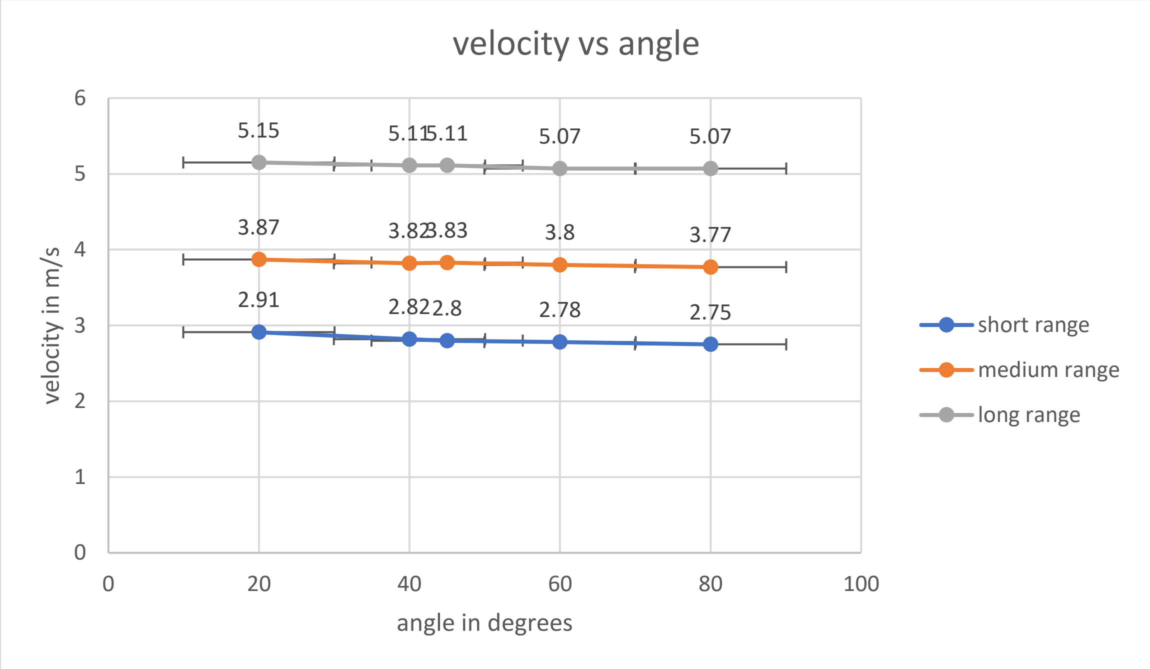
4. 60

Run	Range type	Time between photogates	Velocity(m/s)	Average velocity	Uncertainty in velocity
1	Short range	0.035794	2.79	2.78	0.010
2		0.035866	2.79		
3		0.036106	2.77		
4		0.036106	2.77		
1	Medium range	0.026251	3.81	3.80	0.005
2		0.026382	3.81		
3		0.026344	3.80		
4		0.026260	3.81		
1	Long range	0.019684	5.08	5.07	0.005
2		0.019736	5.07		
3		0.019684	5.08		
4		0.019684	5.08		

5. 80 degrees

Run	Range type	Time between photogates	Velocity(m/s)	Average velocity	Uncertainty in velocity
1	Short range	0.036364	2.75	2.75	0.005
2		0.036304	2.75		
3		0.036293	2.76		
4		0.036255	2.76		
1	Medium range	0.026600	3.76	3.77	0.01
2		0.26485	3.78		
3		0.026489	3.78		
4		0.026550	3.77		
1	Long range	0.019714	5.07	5.07	0.01
2		0.019684	5.08		

3		0.019730	5.07		
4		0.019760	5.06		

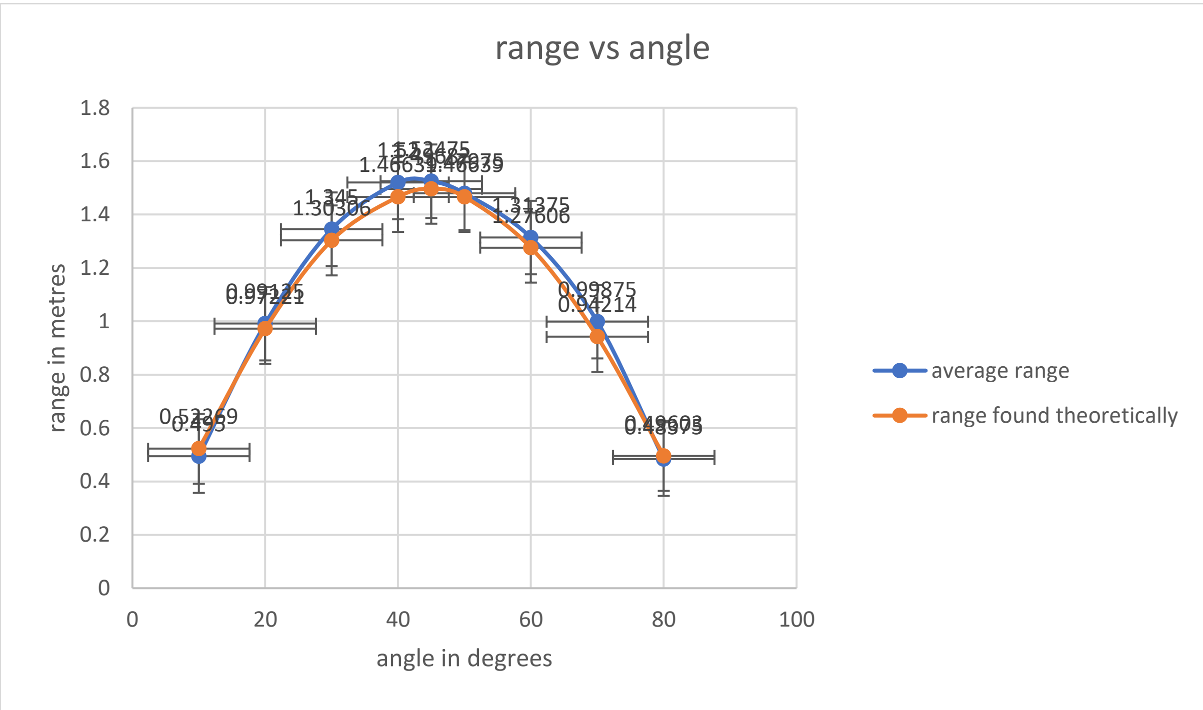


Part B:

Theoretical value of range calculated using equation(iii) and the values found practically mentioned in the table below

angle	run	Time	Velocity	Average velocity	Range	Average range	Theoretical value of range
10	1	0.025766	3.88	3.87	0.50	0.49500	0.52269
	2	0.025820	3.87		0.49		
	3	0.025753	3.88		0.50		
	4	0.025848	3.87		0.49		
20	1	0.025957	3.85	3.85	0.98	0.99125	0.97221
	2	0.025795	3.88		1.00		
	3	0.025806	3.88		0.99		
	4	0.025833	3.87		0.995		
30	1	0.026054	3.84	3.84	1.345	1.34500	1.30306
	2	0.025978	3.85		1.35		
	3	0.026039	3.84		1.345		
	4	0.026123	3.83		1.34		
40	1	0.026124	3.83	3.82	1.525	1.5200	1.46639
	2	0.026098	3.83		1.515		
	3	0.026039	3.83		1.52		
	4	0.026207	3.82		1.52		
45	1	0.026119	3.83	3.83	1.519	1.52475	1.49682
	2	0.026100	3.83		1.525		
	3	0.026062	3.84		1.525		
	4	0.026207	3.84		1.53		

50	1	0.026192	3.82	3.82	1.48	1.47975	1.46639
	2	0.026100	3.82		1.472		
	3	0.026245	3.82		1.479		
	4	0.026115	3.83		1.488		
60	1	0.026251	3.81	3.80	1.315	1.31375	1.27606
	2	0.026264	3.81		1.31		
	3	0.026344	3.80		1.31		
	4	0.026260	3.81		1.32		
70	1	0.026370	3.79	3.79	0.99	0.99875	0.94214
	2	0.026382	3.79		1.01		
	3	0.026409	3.79		0.99		
	4	0.026333	3.80		1.005		
80	1	0.026600	3.76	3.77	0.49	0.48375	0.49603
	2	0.026485	3.78		0.47		
	3	0.026489	3.78		0.50		
	4	0.026550	3.77		0.475		



Discussions

The range found theoretically and the one found practically is almost similar in nature with very minor difference in the distance covered. This is due to the factors such as temperature, humidity, variation of g with the height et cetera. Since the practical was done near the sea, the humidity would be high, but the gravitational constant ‘g’ will not vary much.

From the above graph, it is clear that with the small angle, the range is much shorter. As the angle is increased, the range increases but till the angle of 45^0. However, after 45^0 the range starts to decrease.

This can be explained with the help of equation (iii). i.e. range= $v_0^2 Sin2\theta/g$. g in the equation is constant. Since the velocity will be constant because the ball is thrown with a medium type range from the cannon. This means the range is proportional to Sin2θ

Range $\propto$ Sin2θ

Since $0 \le Sin2\theta \le 1$

The maximum value of Sin2θ will be 1

$Sin2\theta = 1$

$2\theta = 90^0$

$\theta = 90^0/2$

$\theta = 45^0$

this means that the range of a projectile thrown is maximum at 45^0.

Conclusions

- The ball travels the maximum horizontal distance when thrown at 45^0.
- The range increases initially up to 45^0 then decreases thereafter.
- The graph between the velocity and angle shows the different muzzle speed for each of the range thrown.
- The theoretical range and practical range are almost similar in value as can be seen from the graph.

References

- Deakin university, SEB101 lab manual 2019.
- Fundamentals of physics by Resnik, Halliday and Walker, (10^{th} edition)