Ball Off Table

**Introduction**

**Purpose** To review vector components using a horizontal projectile.

**Discussion**

 A projectile is an object upon which the only force acting is gravity. There are a variety of examples of projectiles: (1) an object dropped from rest is a projectile (*provided that the influence of air resistance is negligible*); (2) an object which is thrown vertically upwards is also a projectile (*provided that the influence of air resistance is negligible*); (3) an object which is thrown upwards at an angle is also a projectile (*provided that the influence of air resistance is negligible*); and (4) an object which is launched horizontally off a cliff or table, etc. and falls due to gravity.

**Hypothesis**

If the projectile height and distance are known, then the initial launch angle and velocity can be accurately calculated.

**Materials** Tennis Ball Table Meter Stick

**Procedures**

1. It would be helpful to work in pairs or teams: ball controller, measurer, receiver.

2. Practice to develop a relatively constant speed to roll the ball off the table for so the ball hits 1 meter off end of table.

V

1 m

@

3. Roll the ball off the table and measure the horizontal distance the ball lands from the table and the vertical drop of the ball.

4. Time how long it takes for the ball to travel from the very edge of the table (as it exits the table) to the 1-meter mark on the floor.

5. Show all work and be sure to include units in all measurements, including in your work.

**Calculations and Data**

1. Complete the table with the appropriate information:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Horizontal Distance (from table)dx | Vertical Drop (from table top)dy | Time (table to floor) | Angle (table to floor) | Initial SpeedVx | Final SpeedVy = gt |
|  |  |  |  |  |  |

2. Make a vector sketch of all components from the table above.

3. Calculate the initial speed of the ball leaving the table (show work) and record in the table.

4. Calculate the angle of fall of the ball relative to the horizontal plane of the table (show work) and record in the table.

5. Calculate the initial speed of the ball leaving the table (show work) assuming that you did NOT have a time measurement.

6. Calculate the final speed of the ball leaving the table using the vertical component only (show work) and record in the table.

Hang Time

**Introduction**

**Purpose** To review vector components using a horizontal projectile.

**Discussion**

Hang time is the time it takes a projectile to travel upwards to its maximum vertical height and back down to the ground. For vertical launch angles, the time it takes to reach maximum vertical height equals the time it takes to return to the ground.

**Hypothesis**

If the projectile hang time and horizontal launch distance are known, then the initial projectile height, launch angle and instantaneous velocity of impact can be accurately calculated.

**Materials** Football Gym/Outdoors Meter Stick Timer

**Procedures**

1. Work in teams of three, assigning the following tasks: punter, measurer/receiver, timer.

2. Punt the ball and record the time it takes to go from the person’s foot to its highest point to the ground. This is the hang time.

3. Record the total distance that the punt goes.

4. Show all work and be sure to include units in all measurements, including in your work.

**Calculations and Data**

1. Complete the table with the appropriate information:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Hang Time2t | Horizontal Distance2dx | Heightdy | Instantaneous Velocity (Vy) | Initial SpeedVi | Initial Angle@ |
| 3 s |  |  |  |  |  |

2. Make a vector sketch of all components from the table above.

3. Calculate the height the ball reached.

4. Calculate the instantaneous velocity (Vy = gt) of the football when it hit the ground.

5. Calculate the initial speed of the ball leaving one’s foot (show work) and record in the table.

6. Calculate the angle of delivery of the ball relative to the horizontal plane (show work) and record in the table.

7. Why was hang time designated as “2t”?

Ball Off Table

**Calculations and Data**

1. Complete the table with the appropriate information:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Horizontal Distance (from table)dx | Vertical Drop (from table top)dy | Time (table to floor) | Angle (table to floor) | Initial SpeedVx | Final SpeedVy = gt |
| 1 m | 1 m | .5 s | 45° | 2.2 m/s | 4.4 m/s |

2. Make a vector sketch of all components from the table above.

Vx

dy

dx

@

3. Calculate the initial speed of the ball leaving the table (show work) and record in the table.

**Vx = dx / t**

4. Calculate the angle of fall of the ball relative to the horizontal plane of the table (show work) and record in the table.

**Tan** @ = dx / dy … @ = tan-1 dx / dy = tan-1(1 m/1m) = 45°

5. Calculate the initial speed of the ball leaving the table (show work) assuming that you did NOT have a time measurement.

*Calculate the vertical component of time using: dy = Vit + ½ gt2 … The initial velocity in the “y” directions is 0. Therefore, dy = ½ gt2*

*find time … t = √(2dy/g)*

*e.g. assume dy = 1 m and dx = 1 m t =* √*(2(1)/(10 m/s*2*)) = 0.45 s*

*Vx = d/t = 1 m/0.45 s = 2.22 m/s*

6. Calculate the final speed of the ball leaving the table using the vertical component only (show work) and record in the table.

*Vy = gt … use “t” from #5 … Vy = (9.8 m/s2)(0.45 s) = 4.4 m/s*

Hang Time

**Calculations and Data**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Hang Time2t | Horizontal Distance2dx | Heightdy | Instantaneous Velocity (Vy) | Initial SpeedVi | Initial Angle@ |
| 3 s | 20 m | 11.25 m | 15.0 m/s | 16.4 m/s | 42° |

2. Make a vector sketch of all components from the table above.

Vi

Vy

Vx

@

dx

dy

Vi

@

Vy

3. Calculate the height the ball reached.

 *use half of the hang time to determine the time it took to fall from its highest point*

 dy = ½ gt2= ½*(9.8 m/s*2*)(1.5 s)*2*= 11.0 m*

4. Calculate the instantaneous velocity (Vy = gt) of the football when it hit the ground.

 *use half of the hang time to determine the time it took to fall from its highest point; this will equal the instantaneous velocity at the point it hits.*

 Vy= gt = *10 m/s*2*(1.5 s) = 15.0 m/s*

5. Calculate the initial speed of the ball leaving one’s foot (show work) and record in the table.

 *Calculate the horizontal velocity (Vx) by using half the total distance with half the hang time. In this case you could also use total distance divided by total time.*

 *Vx = d/t = 10 m/1.5 s = 6.7 m/s*

 *Calculate the initial velocity (Vi) by using vector diagram above:*

*Pythagorean theorem: Vi*2 *= Vx*2 *+ Vy*2 … Vi = √[(6.7 m/s)2 + (15.0 m/s)2] = 16.4 m/s

6. Calculate the angle of delivery of the ball relative to the horizontal plane (show work) and record in the table.

 Tan @ = Vy/Vx … rearrange to @ = tan-1 (Vy/Vx) = tan-1 (15 m/s /16.4 m/s) = 66°

Sin @ = Vy/Vi … rearrange to @ = tan-1 (Vy/Vi) = tan-1 (15 m/s /16.4 m/s) = 66°

Cos @ = Vx/Vi … rearrange to @ = tan-1 (Vx/Vi) = tan-1 (15 m/s /16.4 m/s) = 66°

7. Why was hang time designated as “2t”?

 *The time it takes a ball to reach its highest point from the starting point is the same as the time it takes to travel from the highest point back down to the starting point. Therefore, hang time is double the vertical component for time.*