**Introduction** This activity shows how work can change due to friction.

**Purpose** To demonstrate the principle of work & its relationship to PE & KE.

**Background**

Work is the force applied on an object and the distance that force operates. For work to be done, an object must move through a distance: W = f x d.

**Hypothesis**

If a ball is dropped and allowed to rebound off the ground, then the work done in falling to the floor will be greater than the work done in rebounding off the floor due to friction.

Rebound

distance

**Materials** Super Ball Meter stick

**Procedures**

1. Obtain a meter stick and a super ball.
2. Hold the meter stick vertically.
3. Hold the super ball at the top of the meter stick.
4. You will drop the super ball, allow it to rebound, and measure the distance of rebound to the nearest centimeter.
5. Drop the super ball for a total of five trials and calculate the average rebound distance.
6. Measure the mass of the super ball and then convert that mass into kilograms and Newtons.

**Calculations and Data**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Rebound Distance | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 | Average |
| Super Ball |  |  |  |  |  |  |

Mass of the super ball: \_\_\_\_\_\_\_\_\_\_

Mass of the super ball in kg: \_\_\_\_\_\_\_\_\_\_ *(g x 1 kg / 1000 g = kg)*

Force applied by the super ball in Newtons: \_\_\_\_\_\_\_\_\_\_ *(f = W = mg 🡪 mass x gravity)*

1. How does the rebound height compare with the original height of the super ball?

2. If everything was ideal conditions and an ideal situation, do you think the rebound height would equal the original height? Explain your answer.

3. Make a sketch of the super ball (*to the right*) at its highest point before dropping it, to the point it rebounds off the floor and then to the highest point it rebounded. Label the Maximum Potential Energy and the Maximum Kinetic Energy.

4. Calculate the maximum amount of work done by the super ball when it dropped and when it rebounded. SHOW WORK. W = f x d

 Work done when dropped: \_\_\_\_\_\_\_ joules

 Work done on rebound: \_\_\_\_\_\_\_ joules

5. Calculate the maximum PE of the super ball. SHOW WORK. PE = mgh

6. Calculate the maximum KE of the super ball assuming it takes 0.45 s to drop to the floor. First calculate the instantaneous velocity when the ball hits the floor using: v = gt. Then, calculate KE using: KE = ½ mv2. SHOW WORK.

**Conclusions**

Address Hypothesis

Analysis (Optional for this lab)

1. What can you say about the work done in dropping the ball versus the work done in rebounding off the floor? What factor(s) cause these two values to be unequal?

2. Calculate the maximum amount of work done by the super ball if you raise it to 2 meters off the floor. SHOW WORK. W = f x d

3. Which procedures did more work: dropping the super ball from 1 m or from 2 m?

4. In which procedures would the super ball have a greater velocity when hitting the floor, if dropping from 1 m or from 2 m?

5. How are work and PE related?

6. Relate the concept of kinetic energy to work based on this experiment.

**ANSWERS**

**Calculations and Data**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Rebound Distance | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 | Average |
| Super Ball | →  | →  | →  | →  | →  | 0.7 m |

Mass of the super ball: **7.5 g**

Mass of the super ball in kg: **0.0075 kg** *(g x 1 kg / 1000 g = kg)*

Force applied by the super ball in Newtons: **0.075 N** *(f = W = mg 🡪 mass x gravity)*

1. How does the rebound height compare with the original height of the super ball?

  ***It does not bounce back to the original height because of friction.***

2. If everything was ideal conditions and an ideal situation, do you think the rebound height would equal the original height? Explain your answer.

***Yes. If friction is ignored, total energy will remain constant and not transformed into heat. The maximum PE would stay the same before and after dropping.***

Max PE

Max KE

Total E = PE + KE

3. Make a sketch of the super ball (*to the right*) at its highest point before dropping it, to the point it rebounds off the floor and then to the highest point it rebounded. Label the Maximum Potential Energy and the Maximum Kinetic Energy.

4. Calculate the maximum amount of work done by the super ball when it dropped and when it rebounded. SHOW WORK. W = f x d

 Work done when dropped: **0.075 joules** W = 0.075 N x 1 m

 Work done on rebound: **0.053 joules** W = 0.075 N x 0.70 m

5. Calculate the maximum PE of the super ball. SHOW WORK. PE = mgh

*PE = mgh = (0.0075 kg)(10 m/s/s)(1 m) =* ***0.075 J***

6. Calculate the maximum KE of the super ball assuming it takes 0.45 s to drop to the floor. First calculate the instantaneous velocity when the ball hits the floor using: v = gt. Then, calculate KE using: KE = ½ mv2. SHOW WORK.

*v = gt = (10 m/s/s)(0.45 s) = 4.5 m/s*

*KE = ½ mv2 = ½ (0.0075 kg)(4.5 m/s)2 =* ***0.076 J***

**Conclusions**

Address Hypothesis

The hypothesis that if a ball is dropped and allowed to rebound off the ground, then the work done in falling to the floor will be greater than the work done in rebounding off the floor due to friction was confirmed.

Analysis

Work is the force applied on an object and the distance that force operates. For work to be done, an object must move through a distance: W = f x d. In this lab, the work done was twofold: 1) the ball falling and 2) the ball rebounding. The work done in falling is the weight of the ball times the distance the ball fell. The work done in rebounding is the weight of the ball times the distance the ball rebounded.

The falling ball did more work than the rebounding ball because of friction. When the ball hit the floor, the ball recoils and rubs against the floor, reducing the work output. The energy “lost” is due to the recoil and friction on the ball.

1. What can you say about the work done in dropping the ball versus the work done in rebounding off the floor? What factor(s) cause these two values to be unequal?

***The work done in dropping the ball was greater than the work done in rebounding. Energy is transformed into heat (friction) and the collision of the ball with the floor is NOT perfectly elastic.***

2. Calculate the maximum amount of work done by the super ball if you raise it to 2 meters off the floor. SHOW WORK. W = f x d

 Work done when dropped 2 m: **0.15 joules** W = 0.075 N x 2 m

3. Which procedures did more work: dropping the super ball from 1 m or from 2 m?

***The work done in dropping the ball from 2 m is greater than the work done in dropping 1 m***

4. In which procedures would the super ball have a greater velocity when hitting the floor, if dropping from 1 m or from 2 m?

***The ball will have a greater velocity (v = gt) when dropped from a greater height***

5. How are work and PE related?

 ***PE incorporates work. PE = mgh and W = mg***

6. Relate the concept of kinetic energy to work based on this experiment.

***The maximum KE would equal the work done (0.075 J in this lab) if we assume no friction.***