Lesson 3, Bouncing Balls Activity (for High School) – Bouncing Balls Worksheet — Answers

Data

Ball Types:

Ball 1: **Tennis Ball**

Ball 2: **Bouncy Ball**

Ball 3: **Wiffle Ball**

Surface Types:

Surface 1: **Tiled Floor**

Surface 2: **Wood table**

Surface 3: **Particle Board**

1. Based on the **Height** of the bounce for each ball, is the collision more elastic or inelastic? Fill in the table accordingly.

Case	Ball	Surface	Mass of Ball (kg)	Bounce Height (m)	Elastic or Inelastic
1	1	1	.0578	.65	Elastic
2	2	1	.0514	.79	Elastic
3	3	1	.0058	.43	Inelastic
4	1	2	.0578	.63	Elastic
5	2	2	.0514	.75	Elastic
6	3	2	.0058	.45	Inelastic
7	1	3	.0578	.61	Elastic
8	2	3	.0514	.76	Elastic
9	3	3	.0058	.44	Inelastic

Calculations and Results

2. Calculate the velocity of each ball right before it hits the surface (Starting Velocity). Why do you only have to perform this calculation once?

Height(d) = 1m Initial velocity (V_i) = 0m/s Acceleration(a) = gravity = 9.81 m/s^2
Final Velocity (V_f) and time (t) are unknown
By using the Kinematic equations:

$V_f^2 = V_i^2 + 2*a*d$

$V_f^2 = (0m/s)^2 + 2*9.81m/s^2*1m$

$V_f = \sqrt{2*9.81\,m/s^2*1\,m}$

$V_f = 4.43$ m/s

This calculation needs only be performed once because the acceleration of objects is only dependent on the height they are dropped from, the wind resistance, and initial velocity, not the mass of objects. Since we are disregarding wind resistance and all objects are dropped from the same height with no initial velocity, the calculations will be the same.

3. Calculate the velocity of each ball right after it hits the surface (Ending Velocity).

Height(d) = .65m Final velocity (V_f) = 0m/s Acceleration(a) = gravity = 9.81m/s^2
Initial Velocity (V_i) and time (t) are unknown

$V_f^2 = V_i^2 + 2*a*d$

$0 = V_i^2 + 2*9.81m/s^2*0.65m$

$V_i^2 = -2*9.81m/s^2*0.65m$

$V_i = -\sqrt{2*9.81\,m/s^2*0.65\,m}$

$V_i = -3.57$ m/s

By using the same kinematics equation for the rest of the cases, the following velocities were determined:

Surface 2:
$V_i = -3.52$ m/s

Surface 3:
$V_i = -3.46$ m/s

Bouncy Ball:

Surface 1:
$V_i = -3.94$ m/s

Surface 2:
$V_i = -3.84$ m/s

Surface 3:
$V_i = -3.86$ m/s

Wiffle Ball:

Surface 1:
$V_i = -2.90$ m/s

Surface 2:
$V_i = -2.97$ m/s

Surface 3:
$V_i = -2.94$ m/s

4. Calculate the momentum of each ball before it hits the surface (Starting Momentum).

Tennis Ball:
p = m*v where P is momentum, m is mass, and v is the velocity right before the ball hits the surface.
p = 0.0578 kg * 4.43 m/s
p = 0.256 kg * m/s

Bouncy Ball:
p = m*v where P is momentum, m is mass, and v is the velocity right before the ball hits the surface.
p = 0.0514 kg * 4.43 m/s
p = 0.228 kg * m/s

Wiffle Ball:
p = m*v where P is momentum, m is mass, and v is the velocity right before the ball hits the surface.
p = 0.0058 kg * 4.43 m/s
p = 0.0257 kg * m/s

5. Calculate the momentum of each ball after it hits the surface (Ending Momentum).

Tennis Ball:
p is momentum, m is mass, and v is the velocity right after the ball hits the surface

Surface 1:	Surface 2:	Surface 3:
p = m*v	p = m*v	p = m*v
p = 0.0578 kg * 3.57 m/s	p = 0.0578 kg * 3.52 m/s	p = 0.0578 kg * 3.46 m/s
p = 0.206 kg * m/s	p = 0.203 kg * m/s	p = 0.200 kg * m/s

Bouncy ball:

Surface 1:	Surface 2:	Surface 3:
p = m*v	p = m*v	p = m*v
p = 0.0514 kg * 3.94 m/s	p = 0.0514 kg * 3.84 m/s	p = 0.0514 kg * 3.86 m/s
p = 0.203 kg * m/s	p = 0.197 kg * m/s	p = 0.198 kg * m/s

Wiffle Ball:

Surface 1:	Surface 2:	Surface 3:
p = m*v	p = m*v	p = m*v
p = 0.0058 kg * 2.90 m/s	p = 0.0058 kg * 2.97 m/s	p = 0.0058 kg * 2.94 m/s
p = 0.0168 kg * m/s	p = 0.0172 kg * m/s	p = 0.0171 kg * m/s

6. Calculate the change in momentum and the percentage of momentum that was lost for each case.

In each case, we subtract the final momentum from the initial momentum.

For example:

Case 1: 0.256 kg * m/s - 0.206 kg * m/s = 0.05

It is not necessary to have the students show all of their calculations since it is subtraction. However, asking them to show one calculation might be appropriate.

Fill in the Table below with your answers:

Case	Starting Velocity (m/s)	Ending Velocity (m/s)	Starting Momentum (kg*m)/s	Ending Momentum (kg*m)/s	Change in Momentum (kg*m)/s	Percent of Momentum Lost
1	4.43	-3.57	0.256	.206	.050	19.53 %
2	4.43	-3.94	.228	.203	.025	10.96 %
3	4.43	-2.90	.0257	.0168	.0089	34.63 %
4	4.43	-3.52	0.256	.203	.053	20.70 %
5	4.43	-3.84	.228	.197	.031	13.60 %
6	4.43	-2.97	.0257	.0172	.0085	33.07 %
7	4.43	-3.46	0.256	.200	.056	21.88 %
8	4.43	-3.86	.228	.198	.030	13.16 %
9	4.43	-2.94	.0257	.0171	.0086	33.46 %

Further Learning

7. Why did all of the balls lose momentum? What happened to the momentum that was lost?

   All of the balls lost momentum because there are no perfectly elastic collisions in the real world. Even the most elastic collisions are slightly inelastic. When a ball bounces, energy is transferred to heat, noise or internal energy, which decreases the amount of momentum.

8. What would have happened if the collisions were perfectly elastic? Use your own words or calculations to help explain your answer.

   If the collisions were perfectly elastic, then no momentum would have been lost during the collision. Therefore, the balls would hit and leave the surfaces with the same velocity. If the balls leave the surface with the same velocity they hit the ground with, they would bounce back to their original height of 1 meter as long as there is no wind resistance.

9. Based on your experiments, which ball would be the best to use for dodge ball? For bowling? Why?

   The Wiffle ball would be the best to use for dodge ball because it has the least amount of momentum. So when it hits you, it is going to hurt the least.

   The Tennis Ball would be the best for bowling because it is the heaviest and will therefore have more momentum than the other balls moving at the same speed. A ball with more momentum is important in bowling because a large momentum is needed to knock over the pins.

10. Which ball and surface from the experiment would be best for playing basketball? What about for street hockey? Why?

    The material used to make the bouncy ball and the tile floor would be the best for playing basketball because you need a ball that can bounce well for dribbling the ball down the court. For street hockey the material used for the wiffle ball and for the tile floor would be the best because it is the least bouncy combination. With street hockey, you do not want the puck, or ball, to bounce because it is very difficult to hit a bouncing ball with your stick. Also, a bouncing ball could cause more injuries from people swinging their sticks up high.

11. All of the sports associations have hired you to develop the next big sport. They want you, as an engineer, to develop a sport that includes components of other sports. Describe your new sport, including what type of ball and surface will be used and why. Remember to discuss momentum and elasticity.

    Responses will vary.