Lesson 5, Ramp and Review Activity – Ramp and Review Worksheet – Answers

Data

1. Measure the mass of your ball and the cup you are using.

2. Measure the height of your ramp and, therefore, the starting height of your ball.

3. Measure the distance traveled by the cup of three different trials, and find the average distance traveled.

Mass of Ball (kg)	Mass of the Cup (kg)	Initial Height of the Ball (m)	Distance Traveled by the Cup (m)
0.0455	0.0160	0.220	0.285
0.0455	0.0160	0.220	0.280
0.0455	0.0160	0.220	0.300
0.0455	0.0160	0.220	Avg: 0.288

Calculations and Results

4. Calculate the potential energy of the ball before it is released and the kinetic energy right before it hits the cup. What assumption do you have to make to find the kinetic energy?

Potential Energy:
E_p = mgh
E_p = (0.0455 kg)*(9.81 m/s2)*(0.220m)
E_p = 0.0982 Joules

Kinetic Energy:
Energy before ball is released has to equal the energy right before the ball hits the cup according to the law of conservation of energy.
Right before the ball hits the cup, its height is 0 m; therefore, it only has kinetic energy.
$E_p = E_k$
E_k = 0.0982 Joules

To find the kinetic energy, you have to assume that there is no friction exerted on the ball as it rolls down the ramp. We also do not consider the rotational energy for this problem.

5. Calculate the velocity and momentum of the ball right before it hits the cup.

Velocity:
$E_k = ½ * m * v^2$ where m = mass of the ball and v = velocity of the ball
0.0982 Joules = ½ * (0.0455 kg) * v^2
v = 2.08 m/s

Momentum:
p = m * v where p = momentum, m = mass, and v = velocity
p = (0.0455 kg) * (2.08 m/s)
p = 0.0945 kg * m/s

6. Calculate the work done by friction to stop the ball.

$W = E_f – E_i$ where W = work, E_f = Final energy, and E_i = Initial Energy
W = 0 Joules – 0.0982 Joules
W = 0.0982 Joules

7. Calculate the frictional force on the cup and the coefficient of friction between the cup and the surface. What assumption is being made?

Frictional Force:
The work done by the friction force was 0.0982 Joules
W = F * d where d = distance traveled, F = applied force (in this case, friction)
0.0982 Joules = F * 0.288 m
F = 0.341 Newton

Coefficient of Friction
$F_f = \mu * N$ where μ = coefficient of friction, N = normal force
0.341 Newtons = μ * (0.0455 kg + 0.0160 kg)(9.81 m/s^2)
$\mu = 0.565$

We are assuming that the coefficient of kinetic friction and the coefficient of static friction are equal. This makes the calculations much simpler.

8. Fill in the table below with your results.

Potential Energy (Joules)	**0.0982**
Kinetic Energy (Joules)	**0.0982**
Velocity (m/s)	**2.08**
Work (Joules)	**0.0945**
Momentum (kg*m/s)	**0.0982**
Frictional Force (Newton)	**0.341**
Coefficient of Friction	**0.565**

Further Learning

9. By what factor would the velocity of the ball right before it hits the cup increase if the height of the starting position of the ball was doubled? Quadrupled?

$mgh = \frac{1}{2}mv^2$ **The mass values cancel**
$gh = \frac{1}{2}v^2$
$v = (2gh)^{\frac{1}{2}}$ **2g is a constant and wont be affected by a change in h, therefore we can disregard it.**
So v is dependent on h as follows:
$v = (h)^{\frac{1}{2}}$
When h is doubled, $v = (2h)^{\frac{1}{2}}$ so v increases by a factor of $(2)^{\frac{1}{2}}$.
When h is quadrupled $v = (4h)^{\frac{1}{2}}$ so v increases by a factor of 2.

10. How could you decrease the distance the cup travels? How could you increase it?

I could decrease the distance the cup travels by making the ramp lower. If the ball started rolling at a lower position, it would have less energy when it hit the cup. The result would be that the force of friction would have to do less work on the cup to bring it to rest. Since the mass of the ball and the coefficient of kinetic friction remain constant, the force due to friction will also remain constant. So the only way less work will be done is if the mass does not move as far. Increasing the height of the ramp would have the opposite effect and the cup would travel farther. Note: An increase or decrease in the mass of the ball would affect energy and the frictional force so the cup would move the same distance. The only case when this isn't true is if the ball is so light that it doesn't hit the cup with a strong enough force to overcome static friction.

11. As an engineer, how would the knowledge of how to find the coefficient of friction between two materials be helpful when designing a roller coaster?

If I were designing a roller coaster, I would have to know what the coefficient of friction between the wheels and the track is. Knowing what the coefficient of friction is would determine how fast the roller coaster can go and whether or not I would have to make an incline for turns. I would need to make sure that it does not go so fast that the wheels come off the track during a turn.