Lesson 4, Sliders Activity – Slip Slidin' Away Worksheet – Answers

Static Friction

Data:

1. Measure the mass of the empty box and the empty basket. Record this number in the table below.
2. Add the required weight to the box and record this amount.
3. *Gently* add weight to the basket. Record how much weight is in the basket when the box begins to slide. Why is it important to gently (and gradually) add the weight to the basket?
   If the weight is dropped, rather than gently added, it will have more momentum when it

   hits the basket and possibly cause the basket to fall rapidly, and consequently ruin your

   data.
4. Fill in your data in the table below.

Weight of Empty Box (kg)	Weight of Empty Basket (kg)	Weight in Box (kg)	Weight in Basket (kg)	Total Weight of Basket (kg)	Total Weight of Box (kg)
0.276	**0.009**	**0.05**	**0.122**	**0.131**	**0.281**
0.276	**0.009**	**0.2**	**0.189**	**0.198**	**0.476**
0.276	**0.009**	**0.5**	**0.289**	**0.298**	**0.776**
0.276	**0.009**	**0.906**	**0.309**	**0.440**	**1.182**

Calculations and Results:

5. Calculate the normal force of the box for each case.

   Normal Force = Weight
   Normal Force = m*g
   Normal Force = 0.281 kg * 9.81 m/s^2
   Normal Force = 2.76 Newton
   Normal Force$_2$= 4.67 Newton
   Normal Force $_3$= 7.61 Newton
   Normal Force $_4$= 11.60 Newton

(If students are familiar with Free Body Diagrams you could require them to draw one here).

6. Calculate the coefficient of static friction (μs) for each case using the normal force of the box and the force that made the box start moving. Calculate the average μs.

    For each case calculate the force of friction by calculating the force from the basket:
    $F_f = m*g$
    $F_f = 0.131 \text{ kg} * 9.81 \text{ m/s}^2$
    $F_f = 1.29 \text{ Newton}$
    $F_f = \text{Normal Force} * \text{Coefficient of Friction}$
    $1.29 \text{ Newton} = 2.76 \text{ Newton} * \mu_s$
    $\mu_s = 0.467$
    Repeat these steps for the other cases.

μ_s
0.467
0.416
0.384
0.372
Avg: **0.410**

Kinetic Friction
Data:

7. Set up the experiment the same as before, except this time position the basket so that it is close enough to the floor in order to land before the box goes over the edge of the table. Measure the distance from the edge of the box to the edge of the table and the distance from the ground to the bottom of the basket.
8. Use a piece of tape or washable marker to mark the starting position of the box so that you do not have to re-measure it for every trial.
9. Place the same amount of weight in the box, but add more weight in the basket than is required to overcome static friction. Release the basket, and time how long it takes for the basket to hit the ground. Record your data in the table below.
10. Measure the distance from the box to the table edge.

Weight in Box (kg)	Distance to Table Edge – Initial (m)	Distance from Floor to Basket (m)	Time to Hit the Floor (s)	Distance to Table Edge – Final (m)
0.05	0.46	0.21	0.74	0.21
0.2	0.46	0.21	1.26	0.2375
0.5	0.46	0.21	1.16	0.235
0.906	0.46	0.21	0.98	0.23

Calculations and Results

11. For each trial, calculate the speed the basket was moving right before it hit the floor.

Use the kinematics equations to solve:
$d = (v_i + v_f)/2 * t$ The basket started at rest so the initial velocity is zero.
By plugging in the measured values, we can calculate the final velocity.
0.21 m = v_f / 2 * 0.74 s
v_f = 0.568 m/s
Perform the same steps for the other trials.

12. For each trial, calculate the kinetic energy of the box right as the basket hits the floor.

The box has to be traveling at the same speed as the basket, therefore the speed of the basket before it hits the ground will be equal to the speed of the box.
KE = ½ * m * v^2
KE = ½ * 0.281 kg * 0.568^2 m/s
KE = 0.0453 Joules
Repeat these steps for the other trials.

13. Calculate how far the box slid after the basket hit the floor.

Total distance traveled by the box – Total distance traveled by the basket
(0.46 m – 0.21 m) – (0.21 m)
0.04 m
Second Case: 0.0125 m
Third Case: 0.015 m
Forth Case: 0.02 m

14. Calculate the amount of work done by the frictional force on the box after the basket hit the floor.

This value will be equal to the KE of the box calculated earlier.
Work = Initial Energy – Final Energy
Since the final energy will have zero kinetic energy and the potential energy never changes, Work = Initial Kinetic Energy

15. Calculate the frictional force on the box.

The work done by the friction force was 0.0453 Joules
W = F * d where d = distance traveled (question 12), F = frictional force
0.0453 Joules = F * 0.04 m
F = 1.133 Newton
Repeat this process for the other cases.

Weight in Box (kg)	Speed of the Basket (m/s)	Kinetic Energy of Box (Joules)	Work (Joules)	Frictional Force (Newton)
0.05	0.568	0.0453	0.0453	1.133
0.2	0.333	0.0264	0.0264	2.112
0.5	0.362	0.0508	0.0508	3.387
0.906	0.429	0.109	0.109	5.45

16. Calculate the coefficient of kinetic friction for each case and the average.

$F_f = \mu * N$ where μ = coefficient of friction, N = normal force
1.133 Newtons = μ * (0.281 kg)(9.81 m/s^2)
μ = 0.411

μ_k
0.411
0.452
0.445
0.470
Avg: 0.4445

Further Learning

17. Why are anti-lock breaks in cars more effective on slick roads than regular breaks? (Anti-lock breaks are used in cars so that when someone slams on their breaks, the breaks lock for a split second and then release, then lock for a quick second again, and so on.)

If someone without anti-lock breaks slams on their breaks, the tires will lock up, and the kinetic friction between the tires and the road stops the car. This is not so bad on a normal road because there is a high coefficient of kinetic friction. However, on icy roads, the coefficient of kinetic friction is much lower. Therefore, when the tires lock up, it takes a lot longer for the car to stop. The anti-lock breaks are useful because they take advantage of the static friction. By allowing the breaks to roll at the speed of the car for a split second before breaking, the car will be slowed down by static friction, which has a higher coefficient of friction than kinetic friction.

18. As an engineer, how would you build a solid structure that is extremely difficult to move and easy to move at the same time. Use the information about friction you just learned.

In order to build a structure that is difficult to move _and_ easy to move at the same time, I would build a structure made of a material so that it has a high coefficient of static friction but a low coefficient of kinetic friction with the surface it is placed on. This way, it will be very difficult to get it moving initially, however, once it has started moving it will take a lot less force to keep it moving.

19. How else could you calculate the coefficient of kinetic friction?

You could also use free-body diagrams and calculate the tension in the string between the box and the basket. First, you would have to calculate the overall acceleration of the basket, and then the overall force being applied to the basket. Then, you could determine the tension in the spring and calculate the frictional force of the box with the tension value.