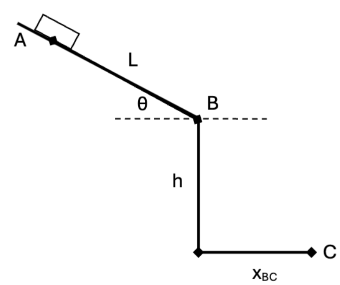
Standard POW Write-up

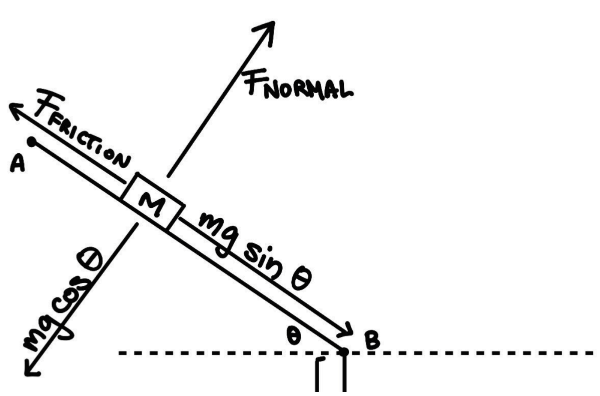
You are expected to address each of the categories listed below unless otherwise directed.
1. Problem Statement: State the problem clearly in your own words. Your problem statement should be clear enough that someone unfamiliar with the problem could understand what it is that you are being asked to do.
A puck with a mass of 72 grams is placed at rest at the top of a ramp that is 2.9 m tall and makes an angle of 38 degrees relative to the horizontal. The ramp is placed on top of a counter that is 1.6 m tall. When the puck slides down the ramp, it lands a certain horizontal distance away from the base of the counter. If the coefficient of friction between the puck and the ramp is 0.17, how far does the puck land from the base of the counter.

2. Process: Describe what you did in attempting to solve the problem, using your notes as a reminder. Include things that didn't work out or that seemed like a waste of time. Do this part of the write-up even if you didn't solve the problem. If you get assistance of any kind on the problem, you should indicate what the assistance was and how it helped you.

A) For this question, we were given a diagram that consisted of all the components we needed which is shown below.



To begin this problem, we broke the diagram into two parts: the ramp (the distance from A to B) and the counter (the distance from B to C). We then drew a free body diagram to display the forces that are applied on the puck.



For this part, our goal was to find the acceleration first and then use that to find the final velocity at when the puck reaches the end of the ramp. But since the problem gives the mass in grams, the first step is to convert grams into kilograms to get the correct units. By dividing 72 grams by

1000 (as there are 1000 grams in one kilogram), we got the mass in kilograms which was 0.072kg. Next, we used Newton's second law of motion and used the formula Force-Ffriction = ma. In this case, mgsinθ represents the force and our mass is 0.072kg so m=0.072, the gravity is 9.8 therefore g=9.8, and then θ represents the angle the ramp is raised by so that would be 38 degrees. Once the numbers are plugged in, that expression is:

$$mg\sin\theta - F_{friction} = ma$$
$$0.072(9.8)(\sin 38) - F_{friction} = 0.072a$$

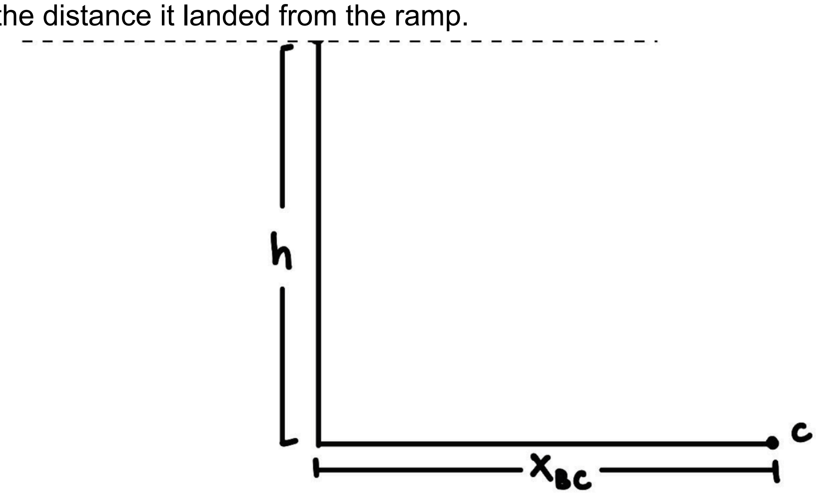
Now we have to plug in values for Ffriction. The formula for the force of friction is Ffriction = Fnormal * μ (the coefficient of friction). It was given that the coefficient of friction between the puck and the ramp is 0.17 therefore μ=0.17. The normal force is equal to the direct vertical force of gravity applied on the object. So since mgcosθ is exactly vertical to Fnormal, Fnormal = mgcosθ. Then once we plug in the values that we got before for m, g, and θ, we can find the expression for normal force which would be 0.072(9.8)(cos 38) and the expression for Ffriction would be 0.072(9.8)(cos 38)(0.17). Finally, once all those expressions are put together and calculated, we can get the value of acceleration.

$$0.072(9.8)(\sin 38) - F_{friction} = 0.072a$$
$$0.072(9.8)(\sin 38) - 0.072(9.8)(\cos 38)(0.17) = 0.072a$$
$$a = 4.72 m/s^2$$

After calculating the acceleration, we plugged that into one of the four kinematics equations, $v^2 = v_o^2 + 2a\Delta y$, to solve for v: the final velocity. Because the object starts at rest, initial velocity is 0 so vo=0. The a is the acceleration that we found before so 4.72 and the vertical distance of the ramp is 2.9 therefore Δy=2.9. Once these values are plugged in, we can find the final velocity of the puck on the ramp.

$$v^2 = v_o^2 + 2a\Delta y$$
$$v^2 = (0)^2 + 2(4.72)(2.9)$$
$$v = 5.23$$

So now that we have the final velocity, we have finished the ramp part of the problem. We then worked on the counter part by using the final velocity to determine the time it took for the puck to land and then the distance it landed from the ramp.



In this part, the final velocity we derived before is used as the initial velocity. When we first started doing this part, we made the mistake of not splitting the initial velocity into the vertical and horizontal components which led us to calculating the wrong time and eventually, the wrong distance. However we noticed our mistake and used the formulas voy = vo * sinθ and vox = vo * cosθ for vertical initial velocity and horizontal initial velocity respectively. Voy and vox are the variables we solve for and vo would be 5.23 (the final velocity from the ramp) and θ=38 as that was the angle from before. The initial velocity components therefore are:

$$voy = vo * \sin\theta$$
$$voy = 3.22$$
$$vox = vo * \cos\theta$$
$$vox = 4.12$$

The second to last step is to solve for the time (t) it takes the puck to reach the ground from the ramp. To find this, we use one of the big four kinematic equations: y = yo + voyt +1/2at^2. Y and yo would be 1.6 and 0 respectively. Voy would be the vertical component of initial velocity which we found before so voy=3.22. Then since the puck is falling, there is a gravitational force of 9.8 so g=9.8. The equation would then be:

$$y = yo + voyt + 1/2at^2$$
$$1.6 = 0 + 3.22t + 1/2(9.8)t^2$$
$$t = 0.33$$

Now the final step to find the horizontal distance is to use the formula Δ x= vox*t. Vox would represent the horizontal initial velocity, a value that we calculated before, therefore vox = 4.12. The value of t is the time it take for the puck to land and is another value that we already derived so t=0.33. When plugged into the equation, we got the horizontal distance the puck traveled which was:

$$\Delta x = vox*t$$
$$\Delta x = 4.12 * 0.33$$
$$\Delta x = 1.36 \text{ m}$$

B) CODE PROCESS

First, we tried to write the code by trying to figure out Δx in terms of combining all the previous equations into one. However, while trying to solve for time, we forgot to include t as t^2. As a result, the original code did not work.

```
System.out.println((Math.cos(num)
        * Math.sqrt(0 + 2 * 2.9 * (0.072 * 9.8 * Math.sin(num) - 0.17 * 0.072 * 9.8 * Math.cos(num)) / 0.072))
        * (Math.sin(num) * (Math.sqrt(
                0 + 2 * 2.9 * (0.072 * 9.8 * Math.sin(num) - 0.17 * 0.072 * 9.8 * Math.cos(num)) / 0.072)))
        / 9.8);
```

Original Code: Num would be imputed through a Scanner

To troubleshoot this, we then decided to work it through step by step. Eventually, we figured out why the first code would not work, but then just decided to rewrite the code to make it understandable.

This time, the code worked and allowed us to solve for the θ that would maximize how far away the puck would land. To figure θ out, we just used trial and error by plugging numbers into the code. First, we went in increments of 10 to see roughly where the best-fit θ was. In the chart below, it shows that θ is between 20 and 30.

Degrees (θ)	Distance (Δx)
10	0.328776334
20	1.421673534
30	1.500560913
40	1.315610846
50	1.04914653

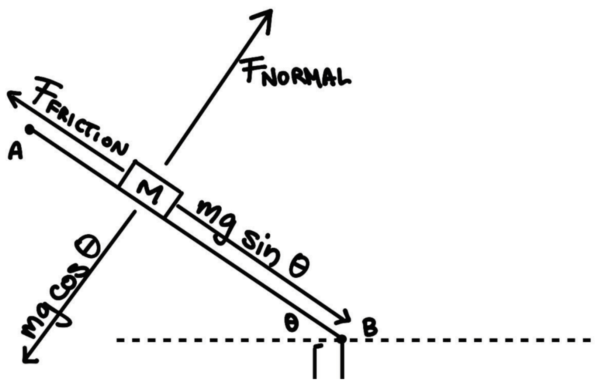
Then, we started narrowing it down to the tenth and hundredth decimal places. We only rounded to the hundredth decimal place because an angle is not more than 2-3 digits.

Tenth's place	Degrees (θ)	Distance (Δx)
	26.4	1.517734805
	26.5	1.517804226
	26.6	1.517838772
	26.7	1.517838792
Hundredth's place	Degrees (θ)	Distance (Δx)
	26.64	1.517842904
	26.65	1.517843076
	26.66	1.517842905

Through trial and error of plugging and chugging, the θ that could maximize how far away the puck would land is 26.65 degrees.

3. Solution: State your solution as clearly as you can. Explain how you know that your solution is correct and complete. (If you obtained only a partial solution, give that. If you were able to generalize the problem, include your general results.) Your explanation should be written in a way that will be convincing to someone else— even someone who initially disagrees with your answer.

1. The first step to the solution for this problem was drawing a free body diagram of the hockey puck.



2. The second step to the solution is to find the acceleration of the puck while on the slanted surface. In order to do this an F=ma equation should be formed which would be F_{net}=mg(sinθ)-mg(cosθ)(μ). Then the F_{net} could be substituted with ma and from there the values would be plugged in to obtain an acceleration value of 4.72m/s^2.
3. Using the acceleration value found in the previous step and the equation $v^2=v_0^2+2a\Delta x$. The corresponding values would then be plugged into this equation to obtain a velocity(v) value of 5.23m/s.
4. Since the next part of the equation is in projectile motion, the velocities/accelerations/displacement could be separated into the x component and the y component. This means that they could each be solved individually. Since there is more information ready to solve for the y value, it is done first. In order to do this, the equation $\Delta x = V_0t+(0.5)(a)(t)^2$ would need to be used. After plugging in the corresponding values, and using the graphing calculator's polynomial solver, a t value of 0.33 is obtained for the free fall motion stage.
5. Then using this t value and the equation $\Delta x=V_0t$, Δx can be solved for. After plugging in the corresponding values a Δx value of 1.36m is obtained.

Code:

We predefined all the numbers we were given in the problem. Then, we just plugged those values into the equations we used for part 1. The code itself should be pretty self-explanatory as all the variable names are representative of the actual variable. Through plug and chug, we were then able to find the right answer for Part B.

```java
import java.util.Scanner;

public class physicsPOW {

    public static void main(String[] args) {
        Scanner scan = new Scanner(System.in);
        System.out.println("Enter number in degrees: ");
        double num = scan.nextDouble();

        scan.close();

        System.out.println("The number just to check: " + num);
        num = Math.toRadians(num);

        double Mass = 0.072;
        double Gravity = 9.8;
        double Mew = 0.17;
        double RampDistance = 2.9;
        double DeltaY = 1.6;

        double Friction = Mew * Mass * Gravity * Math.cos(num);
        System.out.println("This is Friction: " + Friction);

        double Acceleration = ((Mass * Gravity * Math.sin(num) - Friction) / Mass);
        System.out.println("This is Acceleration " + Acceleration);

        double Velocity = (Math.sqrt(2 * Acceleration * RampDistance));
        System.out.println("This is Velocity: " + Velocity);

        double VerticalV = Velocity * Math.sin(num);
        System.out.println("This is Vertical Velocity: " + VerticalV);

        double HorizontalV = (Velocity * Math.cos(num));
        System.out.println("This is Horizontal Velocity: " + HorizontalV);

        double bCoef = VerticalV;
        double aCoef = 4.9;
        double cCoef = -1 * DeltaY;
        double Time = 0;

        if (Math.sqrt(Math.pow(bCoef, 2.0) - 4 * aCoef * cCoef) >= 0) {
            Time = (-1 * bCoef + Math.sqrt(Math.pow(bCoef, 2.0) - 4 * aCoef * cCoef)) / (2 * aCoef);

            System.out.println("This is Time : " + Time);
        }

        double Distance = (((HorizontalV + HorizontalV) / 2) * Time);
        System.out.println("The total distance is: " + Distance);

    }

}
```

4. Extensions: Invent some extensions or variations to the problem. That is, write down some related problems. They can be easier, harder, or about the same level of difficulty as the original problem. (You don't have to solve these additional problems.)

1) Assuming that there is a huge wind howling, it generates a variable force of f(t)=5t^2 + 5t+1.25. Find the jerk throughout the problem and create a graph of this. Then, find the maximum force of the wind and use it to calculate the other values in the problem. (Harder)
2) If this same problem were to be done but a black hole is within 1000 miles, how much force from a space fan would be required to ensure the puck does not fall into black hole? (Harder)

3) If an object was to fall off of the World Trade Center, with a person pushing it with a force of 300 N at an angle of 34 degrees, against a wind with a force of 27 N, assuming the height of the tower is 1776 feet how far would the puck fall and find an angle from where the puck fell to the top of the tower. (Easier)