Investigation: Friction on Inclined Planes

Introduction

Objects on a slope tend to roll downhill due to the force of gravity. Just like objects dropped from a height, they will accelerate as they travel downwards. However, not all ramps are created equal.

Some surfaces allow objects to roll more easily than others. Consider what happens to a car left in neutral on an asphalt road versus a gravel driveway – it is very easy for the car to roll down the road, whereas on gravel it may not roll at all. Liquids like oil or water on the road can make it even easier for the car to roll

In this experiment, we will analyse the motion of objects rolling down a ramp covered with different surfaces. We will be looking at how the surface of the ramp, which has a fixed height and angle, affects the velocity of the object when it reaches the bottom. We will be looking at whether the object starts to roll and how quickly it accelerates.

1. Questioning and predicting

Let us think about the aim of this investigation.

1. Which kinds of surfaces (if any) prevent the object from rolling at all?
2. Which kinds of surfaces result in the greatest acceleration?
3. For a given surface, how does the angle of the ramp affect the results?

HYPOTHESIS

Objects roll more quickly down (smooth/rough) surfaces.

Changing the surface material changes the force due to \_\_\_\_\_\_\_\_.

2. Planning investigation

This investigation has been planned for you.

Divide up into groups. Each group will make a ramp with the same height but a different angle of inclination. Suggested materials for making the ramp are folded cardboard, or a piece of wood propped up on supports. You should collect various materials to cover the ramp: pieces of cloth, carpet samples, water, oil, sand etc.

Every group will receive a toy car to roll down the ramp. This will allow us to model the scenario described in the introduction.

Download an app on your phone which will enable you to measure the speed of the object as it leaves the ramp. Possible suggestions are; “Video Physics (Vernier)” on Apple, and “VidAnalysis Free” on Android.

1. Place the unmodified ramp on a smooth floor.
2. Hold the toy car at the top of the ramp and release it.
3. Have one person use a stopwatch to determine how long it takes for the car to reach the floor.
4. Have a second person use the app to measure the speed of the car just as it leaves the ramp.
5. Record the time and the speed for each ramp surface material.
6. Calculate the average acceleration.
7. Share results with other groups to make a table of acceleration vs. ramp angle for each surface material.

3. Conducting investigation

Each group should fill in a table like this for their ramp.

|  |  |  |
| --- | --- | --- |
| Material | Time to base (s) | Final velocity (m/s) |
|  |  |  |

**Did you make any changes to the method? Did you have design problems to solve? Did you have some ‘smart’ ways of doing the investigation?**

4. Processing and analysing

To calculate the average acceleration of each object, we simply need to know the change in speed and the travel time. The initial speed is always zero, so we can simply divide the final speed by the total time.

Add a column to your previous table with the calculated accelerations.

|  |  |  |  |
| --- | --- | --- | --- |
| Material | Time (s) | Final velocity (m/s) | Average acceleration (m/s2) |
|  |  |  |  |

Describe which surfaces result in the highest accelerations.

Describe which surfaces result in the lowest accelerations.

Are there any surfaces for which the object does not move at all?

You can now compare your results with other groups.

5. Problem solving

Gravity causes the object to accelerate downwards. The force vector points towards the centre of the Earth. We can decompose it into two components, one along the length of the ramp and one perpendicular to the ramp’s surface. The component along the length of the ramp contributes to the downward motion. The steeper the ramp, the larger the magnitude of this component and hence (all other things being equal) we expect the acceleration to be greater.

However, there are other forces that can oppose this motion, decreasing the net force and hence the acceleration. One of those forces is friction.

Friction always opposes the motion of objects; if the object is travelling down the ramp, there will be a friction force directed up the ramp.

6. Conclusions

Friction always \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the motion of an object.

Objects roll more quickly down \_\_\_\_\_\_\_\_ (smooth/rough) surfaces because they provide \_\_\_\_\_\_\_\_\_ (more/less) friction.