ASELL SCHOOLS Advancing Science & Engineering through Laboratory Learning

LABORATORY LEARNING ACTIVITY

Motion on an inclined plane: Teachers notes

Summary

When an object is placed on a flat surface, it will sit still on the surface and won't move unless an outside force causes it to move. However, when the object is placed on an inclined surface, the object will start to slide down the surface due to gravitational forces. These inclined surfaces surround us everywhere. Such examples include when a car is on a hill and when a skateboard is rolling down a ramp. In this experiment, students will utilise their knowledge of acceleration and velocity and investigate how varying the angle of the ramp will affect how fast the object will accelerate down the surface.

Curriculum Outcomes: Victorian Curriculum F-10

Levels 7 and 8

Science and Understanding: Physical sciences

- Change to an object's motion is caused by unbalanced forces acting on the object; Earth's gravity pulls objects towards the centre of Earth (VCSSU103).

Levels 9 and 10

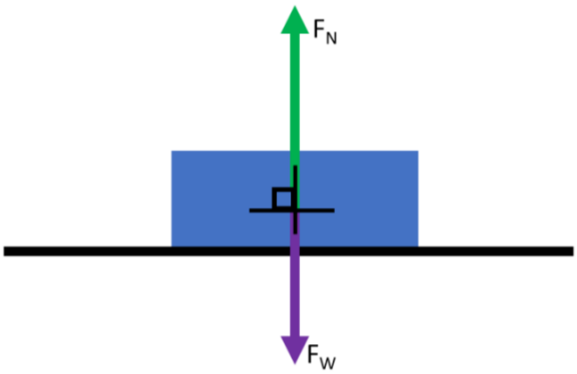
- The description and explanation of the motion of objects involves the interaction of forces and the exchange of energy and can be described and predicted using the laws of physics (VCSSU133).

Key Ideas & Background information

What is an Inclined plane?

To understand the inclined plane first we need to look at forces. Consider this object

While the object is stationary on a flat surface there are two forces acting on it. The Weight Force **(F_W)** and the Normal Force **(F_N)**. The Normal Force is always perpendicular to the plane.



The Weight Force **(F_W)** is found by multiplying the weight with gravity (9.81 N kg^{-1}).

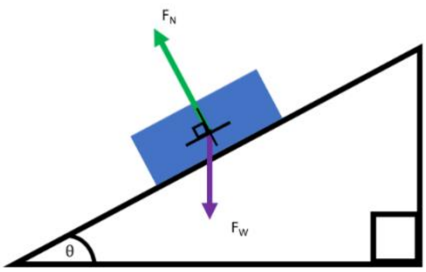
$$\boldsymbol{F_W} = m \times g$$

$$\boldsymbol{F_W} = mg$$

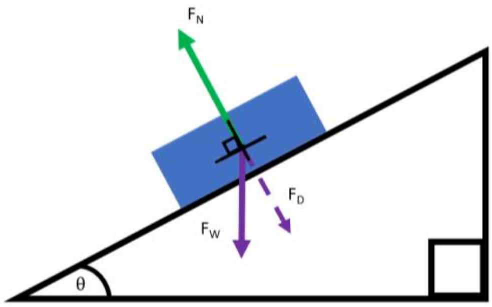
The Normal Force **(F_N)** is equal to Weight Force **(F_W)**. As it is an equal and opposite reaction.

$$\boldsymbol{F_N} = \boldsymbol{F_W}$$

On a flat surface, these two forces are balanced. But if the surface was an incline these forces would become unbalanced.

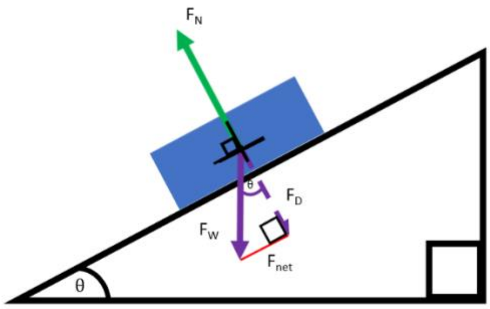


To balance these forces, a force called the Downwards Force **(F_D)** is added.



Combined the Weight Forces **(F_W)** and the Downwards Force **(F_D)** are equal to the normal force

Connecting the Weight Force **(F_W)** and Downward Force **(F_D)** is the Net Force **(F_{net})**. These three forces form a right-angled triangle.



Now that we know all our forces we can calculate the acceleration of the object as it slides down the plane.

To find acceleration we will be using the trigonometry formula

$$\sin\theta = \frac{opposite}{hypotenuse}$$

Each side of the triangle correlation to one of the forces. The hypotenuse is the magnitude of weight force and the opposite is the magnitude of the net force.

To find the magnitude of the Weight Force **(F_W)** we multiple the mass by gravity.

$$\boldsymbol{F_w} = mg$$

Next we rearrange the $\sin\theta$ equation so that the opposite is the subject

$$opposite = \sin\theta \times hypotenuse$$

As the hypotenuse = $\mathbf{F_W}$ and opposite = $\mathbf{F_{net}}$ we substitute them into the equation

$$\boldsymbol{F_{net}} = mg\sin\theta$$

As we know that it is the Net force that is allowing the object to move down the plane, we use newton's second law of motion to make the assumption

$$\boldsymbol{F_{net}} = m \times a$$

Where m = the mass of the object and a = the acceleration of the object down the plane (m/s^2) rearranging the equation gives us

$$a = \frac{\boldsymbol{F_{net}}}{m}$$

Pedagogy

Inquiry

This is an inquiry activity that can be adjusted by the teacher to be as guided or as open-ended as desired. The student notes begin with specific directions, but later questions allow students to conduct more independent investigations. The teacher may, however, decide to provide close guidance and direction throughout the activity.

Extra notes

What could cause outliers?

- Since the time it takes for the cart to travel the full distance is five seconds or less, poor reading of time can significantly change results.
- If the cart is not tracked properly with the camera, reading the data from the video playback will be more difficult and prone to errors.

Tips:

- The stopwatch or phone time is best when it is high contrast, for example the numbers are white, and the background is black. This makes it easier to read off the footage.
- Having the person tracking the cart above solves the parallax issues.
- Students may not be used to making graphs with time as the variable that is changing rather than distance. Explanations may be required so that they realise the difference.
- If a phone is used as a stopwatch, ensure that someone stops the cart at the end of the track so that the phone is not damaged. Also ensure that the phone is securely attached with Blu-tack, so that it does not fall off.
- There are plenty of free spirit-level apps as well as high-contrast stop watch apps that students could download.

Acknowledgement to Authors

Previous authors & scientists involved	Short bio / Staff link (if necessary)
 Dr John Long	John Long is a senior lecturer in the faculty of Science, Engineering and Built Environment at Deakin University. His research is in the field of material science and focuses on atomic emission spectrometry analysis of thin surfaces such as coatings on metals like steel. Staff page link: http://www.deakin.edu.au/about-deakin/people/john-long
 Dr Kieran Lim	Kieran Lim is an Associate Professor in the Faculty of Science, Engineering and Built Environment at Deakin University. His research focuses on how students learn and primarily on forensic science by supporting police and forensic scientists with new science skills and techniques to solve crimes. Staff page link: http://www.deakin.edu.au/about-deakin/people/kieran-lim

References

Van, P Phillipson, L Lim, K Long, J White, P Bentley, I 2017, *Investigation – investigating Velocity, acceleration and gravity*, ASELL Schools.

CarToq, 2016, *Experienced Drivers Never Make These Mistakes,* <https://www.cartoq.com/experienced-drivers-never-make-these-mistakes/>.

Copyright and Creative Commons