KLiC Activity Scenario Template – Informal Setting

Activity title:

Mechanics: Newtonian Physics

Subject:

Informal Physics

Student age:

16+

Estimated duration:

50 minutes (excluding setup time)

Learning content

- Learning Newton's second law of motion, F = ma.
- Learning details about different motion formula involving acceleration (a), Initial velocity (u), final velocity (v), time (t) & distance (s).
- Seeing how these formulas can be adapted to measure the variables for a moving object.

Learning objectives

The aim of the lesson is to teach students the basics of motion using rudimentary physics. The following points will be covered:

- Explanation for the origin of the formula of F = ma
- Comparison of a = F/m with a = (u – v)/t
- Understanding how an accelerometer works
- How gravity is related to the mass and weight of an object
- Practical demonstration of the KLIC accelerometer

Inquiry-based character (if applicable)

Teacher explains the basics behind the maths and physics and through the experiments the students are charged to find if what they have been taught is correct. This is both Teaching guided learning and Discovery based learning.

Applied technology (if any)

KLiC wrist accelerometer and base station with an equivalent number of Laptops and a single projector.

Materials needed (if applicable)

Remote Control Car, classroom.

Description of Activities

Knowledge Building

At the start of the lesson the students and alternative observers will be brought to a demonstration in the class room. This demonstration is designed to have a SensVest wrist accelerometer attached to a remote control car.

At the start of the demonstration a talk will be given to explain briefly the reason for the informal lesson being given. The aim of the lesson is to introduce, in an informal way, the SensVest technology to teachers, students and observers as a teaching tool. It will be explained to the students and observers that the technology works through wireless communication. The SensBall which is turned on and connected to wirelessly transmits its data to the SensVest basestation. The information read out at the receiving end is represented as a graph which plots 4 lines, X, Y, Z and G. When the ball moves in a direction the force applied can be measured as a signal output across the graph. The problem is that the X, Y & Z data can change dramatically due to rotational forces.

The accelerometer will then be attached to a remote control car which will be driven around a small area in the class room while the information is displayed via a projector and the rest of the lesson's content will be delivered after the demonstration.

Remote Control Car

Like most things electrical that run on batteries, remote control cars take in direct current supplied by the battery. This means that when power is drawn from the battery the flow of current keeps its direction. This is important as most motors require the current to be travelling in a specific direction in order to keep the wheel rotating. Motors work by inducing an electromagnetic field around the shaft of the motor causing it to turn, if the motor were to be supplied alternating current the shaft wouldn't move because the current would continuously be changing direction. This means that each motor would need to be supplied by a full wave rectifier to change the alternating current to direct current.

The can receives a signal from the radio frequency transmitter attached to the remote control, from there it determines how much current is supplied to the motors depending on the frequency delivered by the controller and in turn this makes the car move forward.

The wrist accelerometer will be attached to the top of the car and the entire thing weighed to give the total mass. To display to the students and observers how the SensVest technology works the car will drive around with the information displayed by the project. After it's seen and understood how the technology works with the software the experiment will begin, the car will be lined up to travel in a straight line with of a set distance and one of the students assisting in timing the event.

The Physics

In order to introduce to the students and observers the way we can relate the resultant data from the SensVest accelerometer we need to introduce to them to some of the important concepts involved in Newtonian physics.

The simplest of formulas is: $distance = speed \times time$

Also to note that Speed ≠ Velocity. Velocity is speed in a given direction.

It is often useful to give examples when ever presenting different formulas to anyone. In this case it will be proposed that if we have a car travelling at 10 miles per hour (Mph) how many miles will it cover in 3 hours, the answer would be 30 miles.

From there a discussion on how acceleration is the measurement of difference in velocity over a given time and is represented in meters per second squared (m/s^2). For example a car is stopped at a set of traffic lights and the light turns to green, the car take 10 seconds to reach 10 miles per hour. So to work out the acceleration of the car the formula needed is:

$$a = \frac{v - u}{t} \quad acceleration = \frac{final\ velocity\ -\ initial\ velocity}{time}$$

So from there we can set v = 10, u = 0 and t = 10, which means 10/10 = 1 therefore the car is travelling at 1 m/s^2.

Additionally we can work out acceleration by using the distance, initial velocity and time with the formula: $s = ut + \frac{1}{2}at^2$

In the experiment the car will be driven for a set distance and timed to see how long it takes to reach the end of the distance. We also know that the initial velocity is 0.

Additionally the students need to be taught about force and how it affects objects as the wrist accelerometer only returns force and not acceleration through design. Sir Isaac Newton determined that $force = mass \times acceleration$. This can be depicted by Sir Isaac Newton sitting under his apple tree, where an apple of a certain mass fell from the branch and hit him on the head. If you imagine the moment of when the apple is about the fall it has an initial velocity of 0, similar to when the car is about to drive off at the green light, and given the time it takes for apple to hit Sir Isaac Newton it has a final velocity. From this we can surmise that if the apple has a change in velocity over an amount of time then the apple has acceleration. Newton deduced that the only force acting upon the apple during fall was gravity and in the fact that you have the mass of the object and the acceleration of the object, you can work out what the force acting upon the object is $f = m \times a$.

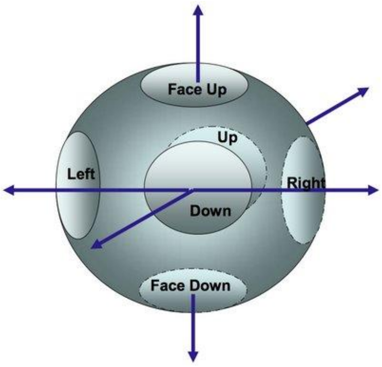
At this point the experiment takes place to show the force of the output of the car through the projector while the assisting student collects the time taken.

With the formula $s = ut + \frac{1}{2}at^2$ and we can rearrange the formula to determine the acceleration. Initially because u = 0 we can say that ut = 0, thus $s = \frac{1}{2}at^2$ and $a = \sqrt{\frac{2s}{t}}$. Thus we can calculate the acceleration of the car.

Now we can determine the acceleration by using the mass of the car + accelerometer and the force read from the SensVest wrist accelerometer. In review of the information we can see that both forms of acceleration are equal.

KLiC Technology

The SensBall is designed to use a three axis accelerometer to calculate the force applied to the ball. The accelerometer is designed with the concept of being able to measure the voltage across six separate plates. Each opposite plate belongs to the same axis but will produce a different voltage due to its direction.



In between all these plates is a crystalline structure designed to conduct a voltage, in the micro volts range, When the crystalline structure makes contact with one or more of the plates it induces a current through the device completing the circuit and allowing us to know what direction the device is travelling.

This does mean that if the accelerometer is at rest that the crystalline structure will be making contact with one of the surfaces and show the downward force of gravity being applied. It is common misconception that all accelerometers measure acceleration, most of them measure force instead.

References

http://2.bp.blogspot.com/-xu_qYRp7rIE/TbjMni4CXbI/AAAAAAAAANo/NU8nCvFjEng/s1600/Remote-Control-Toys-Radio-Control-Car-6-Assorted-W-Light-RCC50545-.jpg
http://www.cartoonstock.com/lowres/shr1352l.jpg
http://smarticle.co.uk/wordpress/wp-content/plugins/wp-o-matic/cache/190c1_rcjAccelerometer.jpg

Assessment (if applicable)

The purpose of this informal scenario is to encourage the basic understanding movement and force. Do measurements with the accelerometer on the toy car, and using both worked out results and results from the KLIC software, determine the direction of the accelerometer mounted on the car.