Rocket – Teacher Notes

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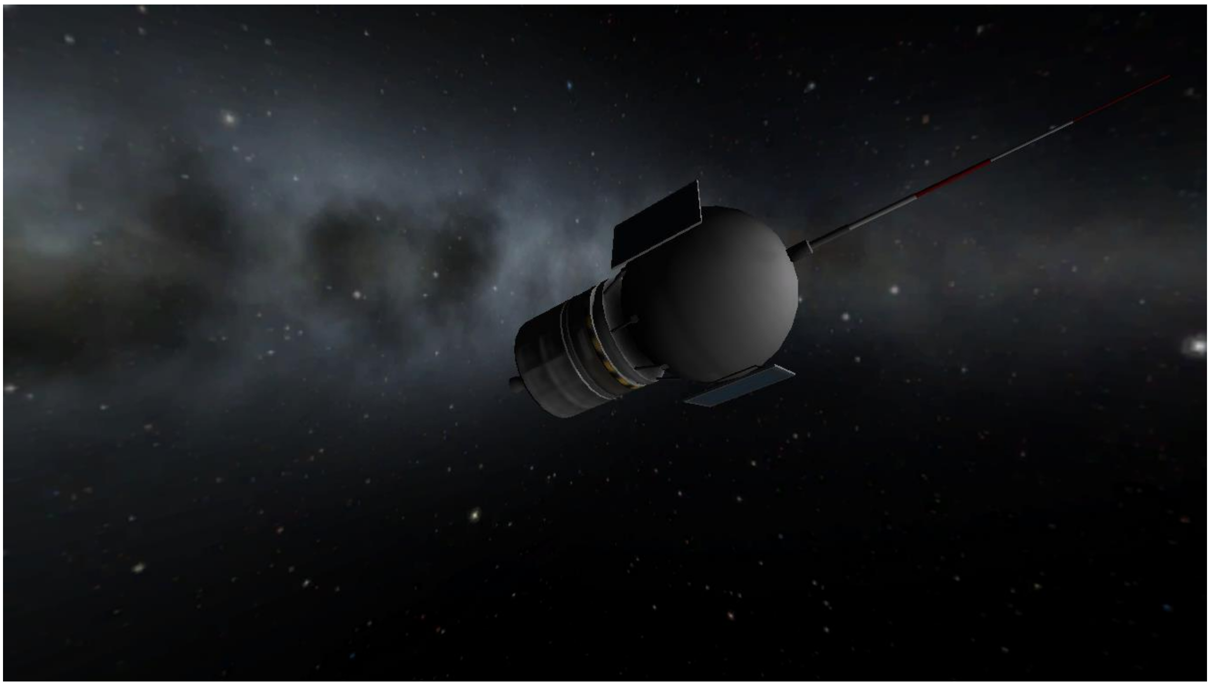

Figure 1 – Integrated Integrals Satellite

Aim

Physics is derived from the Greek word 'phusis' which means 'nature'. It is the study of the laws governing all the natural phenomena of the universe. We use mechanics when we move or move objects; we use thermodynamics when we cook; we use optics when we see objects and acoustics when we hear. An important branch of physics is mechanics which deals with motion and the forces responsible for motion. Your students will learn about Newton's laws of motion and will apply this knowledge when explaining a practical application.

Today's experiment is fun as the students will enjoy setting it up, conducting the experiment and explaining all the forces involved in making the object move. It is a useful experiment, where students will be able to observe the relevance of physics.

Plan

Allow sometime for students to watch a clip about Newton's three laws of motion https://www.youtube.com/watch?v=mn34mnnDnKU . It is important that students understand the laws in order to make a hypothesis and explain their results. They also need to understand the principle of balanced and unbalanced forces and the fact that an object can be subject to a number of forces from different directions but will only move in the direction of the net force. A good clip which explains this is found here: https://www.youtube.com/watch?v=I-iofTyr2VE

Discuss with students the safety precautions that should be considered. These involve using a blowing pump to blow the balloon. Ensuring not to use the mouth to blow a balloon than has been previously blown by someone else and keeping the area clear for the experiment.

Conduct

The students are given a recipe to follow, yet they can be given the opportunity to make changes to their experiment to study how different variables would affect the motion of the balloon rocket. Thus, the experiment is a mix of prescribed and open inquiry. Students will analyse and justify their results to explain the motion of the rocket in terms of Newton's laws.

To set up the experiment, students will do the following steps:

- Tie one end of a string to a chair and tie the other side to a second chair, ensuring that the string is sitting horizontally.
- Thread a straw through the other end of the string and then tie this end to the other chair.
- Tape a drinking straw along the side of a plastic bag. This step can be replaced by sticking the straw to the balloon itself.
- Position the straw at one end of the string.
- Blow up a balloon and place it in the bag or simply stick the inflated balloon to the straw while holding tight the nozzle of the balloon.
- Count down to zero, and let go of the balloon.
- Measure the distance the balloon has travelled.
- Students may need to measure the time of travel using a stop watch if they are going to include velocity in their experiment.
- Repeat the experiment with three different sizes of balloon.
- Repeat each size three times to achieve reliability of results. In order to ensure that the balloon has reached the same size, measure the thickness of the balloon at the widest point. Use a measuring tape to measure how wide the balloon is.
- Average the results.

The teacher may want to add some extensions to the experiment to study different variables other than the volume of air.

1. ***Test for the effect of friction***
   a. In this experiment, students will inflate the balloon to the same size and change the type of the string. They can use fishing string, cotton string or nylon string. They can also use the same type of string and rub oil or dish washing liquid on it to reduce friction. They will compare the distance travelled in each case.
   b. Use the same type of string but use different lengths of the threaded straw.

2. ***Test the effect of angle of launch (for senior classes)***
   Students can either tie the string horizontally (180^0), vertically (90^0) or at an angle (say 45^0) and find how far the rocket will move in each case. Make sure the size of the balloon is similar when launched at different angles.

3. ***For years 7 and 8 make the experiment more fun***
   In addition to the above set-up, students can make a car race using a balloon. They can either design their own cars or use toy cars and stick the inflated balloon using a sticky tape to the top of the car. (Best way to stick the balloon is to use a double face sticky tape or to make loops of sticky tape with the sticky side facing the outside).

4. ***Changing the mass of the balloon (verification of Newton's second law)***
   Repeat the main experiment for the largest size of inflation adding a coin inside the balloon and follow the steps in the main experiment twice. Make sure the rope is long enough in order to be able to observe differences. Ensure that the balloons are inflated to the same size.

Analyse

Students will analyse their results and compare it to their hypothesis. It is best if they tabulate their results.

	Size (cm)	Distance (m)	Time (s)	Velocity (m/s)
Trial 1				
Trial 2				
Trial 3				
Average				
Trial 1				
Trial 2				
Trial 3				
Average				
Trial 1				
Trial 2				
Trial 3				
Average				

Students will practice their unit conversion skills to find the velocity.

Friction experiment

a. i. Change type of string

	Type of string	Distance (m)	Time (s)	Velocity (m/s)
Trial 1				
Trial 2				
Trial 3				
Average				
Trial 1				
Trial 2				
Trial 3				
Average				
Trial 1				
Trial 2				
Trial 3				
Average				

ii. Same type of string with and without lubricant (oil or dish washing liquid)

Without lubricant	**Distance (m)**	**Time (s)**	**Velocity (m/s)**
Trial 1			
Trial 2			
Trial 3			
Average			
With lubricant			
Trial 1			
Trial 2			
Trial 3			
Average			

b. Different length of straw

Length of straw (cm)		**Distance (m)**	**Time (s)**	**Velocity (m/s)**
	Trial 1			
	Trial 2			
	Trial 3			
Average				
	Trial 1			
	Trial 2			
	Trial 3			
Average				
	Trial 1			
	Trial 2			
	Trial 3			
Average				
	Trial 1			
	Trial 2			
	Trial 3			
Average				
	Trial 1			
	Trial 2			
	Trial 3			
Average				

Angle of launch

Angle of launch		**Distance (m)**	**Time (s)**	**Velocity (m/s)**
180^0	**Trial 1**			
	Trial 2			
	Trial 3			
Average				
40^0	**Trial 1**			
	Trial 2			
	Trial 3			

Average				
90^0	**Trial 1**			
	Trial 2			
	Trial 3			
Average				

Fun experiment for years 7 and 8

Students will have a balloon powered car race and find the winning car. They can write their observations about the winning car. This includes the shape of the car, the material, the size of the balloon, etc. They can also measure the distances covered by the car and the time taken (each student can have a role measuring one of the parameters) to calculate the velocity.

Changing the mass of the balloon

		Distance (m)	**Time (s)**	**Velocity (m/s)**
Balloon with coin	**Trial 1**			
	Trial 2			
	Trial 3			
Average				
Balloon without coin	**Trial 1**			
	Trial 2			
	Trial 3			
Average				

Problem solving and discussion

This is the time for students to compare their results to their hypothesis and find whether they agree or not. If they do not agree, they need to find the source of error and decide whether their hypothesis was wrong or if there were any errors when conducting the experiment or in their analysis.

Sources of error could be the amount of air in the balloon. It is possible that air may leak from the balloon after its circumference was measured and before lift-off, which would give wrong results. This is why it is very important to repeat each test to get an average. Also, reaction time when taking measurements on a stopwatch could be minimized if the same student is responsible for this. Something that can affect the results is the size of the nozzle of the balloon, as small nozzles will not allow much air to escape and hence will not provide enough thrust to push the balloon forward. If the balloon has a very big nozzle, air may escape too quickly, causing excessive friction which limits the balloon's movement.

Students will need to explain their results in terms of Newton's laws. Newton's first law is the law of inertia which states that an object remains in its state of rest or uniform motion until acted upon by an unbalanced force. Newton's second law explains the relationship between the net force and the mass and acceleration of an object. It states that acceleration of an object is directly proportional to the net force applied and in the same direction as the net force and inversely proportional to the mass of the object. Newton's third law of motion is the "action-reaction" law, and it states that for every action there is a reaction equal in magnitude and opposite in direction.

Students need to understand the forces acting on the balloon and explain them. There is the thrust force (due to the flow of air backwards) which moves the balloon forward. In the opposite direction there are two forces (friction force and air resistance force) which are trying to stop the balloon. The net force, which is the difference between the thrust and the sum of friction and air resistance forces, is responsible for the motion of the balloon. There is also the gravitational force acting downwards which is balanced with the tension force holding the balloon to the string (in the case of the 180^0 horizontal string) which stops the balloon from falling. For the balloon on the inclined plane, the weight force is balanced with the vertical component of the tension force, whereas in the vertical plane for the 90^0, the air resistance force and the friction force add to the weight force and is counteracted by the thrust force in the opposite direction. Therefore, it is expected that the balloon on the horizontal plane would travel more than the one on the inclined plane, which in turn would travel further than the vertical plane.

The first law is clear in the fact that the balloon does not move until there is an unbalanced force acting on it, represented by the force applied by the air molecules moving out of the nozzle. This force is greater than air resistance and friction, therefore the rocket starts moving.

Newton's second law can be verified in the 'changing balloon mass' experiment. In this experiment, increasing the mass would lead to a lesser acceleration according to the equation:

$$\boldsymbol{a} = \frac{\boldsymbol{F}}{\boldsymbol{m}}$$

So, the balloon with the bigger mass would travel a shorter distance than the one with the smaller mass.

Newton's third law is proved through the action of air that is expelled from the balloon (action) which leads to the forward motion of the balloon, the thrust (reaction).

These experiments could yield more sophisticated results if a logger pro with sensors is available so that students may obtain the velocity at each point and the acceleration.

Conclusion

Students may now state whether their hypothesis was supported or not. They can take photos or video clips of their experiment to include in their final report. They can use an application such as https://prezi.com/ to present their work online.

References:

Link to figure 1 https://www.flickr.com/photos/kordite/17187824349/in/photolist-sbQ6n8-rAk5Ns-c5WbUC-Xz8uEe-e6XGnn-6cuVnH-WCX19L-dRciBu-7PCwws-9NxSCr-WxNmXe-qFJ4kv-5WdLyb-GoQ7mH-pqtwVN-Y63xgS-emLdge-fJBGWi-9NzRNa-bwAaM8-XeWYW9-qXQxkJ-a51euS-kh8nHw-ndGVrt-r69Jhg-qAPTkh-fruFaP-tTJ6S-9bJZNa-qVCack-jxD8Gp-e4Xsj6-8BNuYW-fs8fEc-gf5MXy-fruHic-6WCd8-fruGXg-ayBaTi-8BNv3W-64EpYB-dpHZFu-jxD8xB-8BNvyb-dpoEfD-nQBDSM-fjbvT7-6EPDjC-rGwQWu Author Kordite Licence https://creativecommons.org/licenses/by-nc/2.0/