Thrust Measuring Test Stand - Experiment Lab - Horizontal Forces / Vectors

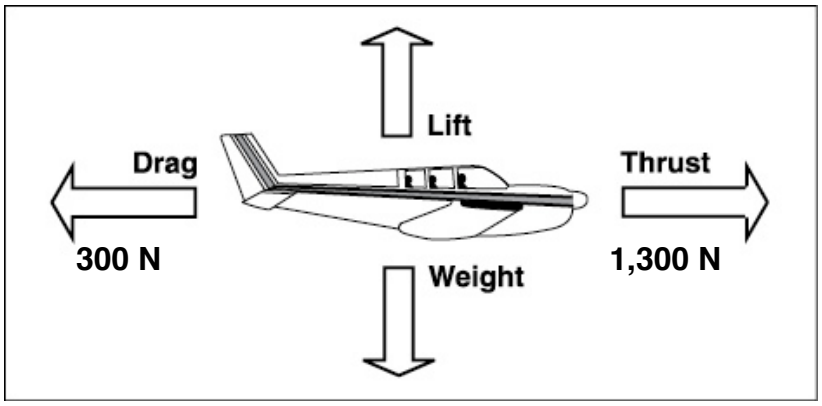
SeaPerch Activity

Review

After completing the lab on vectors and forces, you should recall that vectors are different from measured *scalar* quantities (mass, volume, area, etc.) because they have a given *direction.* When two or more vectors are added together, we get a *resultant vector*. So, the size of the the force in Newtons (N) or pounds (lb.), but we must also think about the direction of the various forces.

We use vectors when describing an object's motion.

For an example, here a plane is thrusting to the east with 1,300 Newtons of force, but there is 300 Newtons of force drag on the plane:



1.) Write and solve an equation that represents the total horizontal motion of the airplane (*hint: remember you can add a negative number to represent an opposite direction*.) Please include arrows to indicate direction.

2.) What do you think are the responsible for causing the *thrust* and *drag* forces?

Vectors, Motors, and SeaPerch

For your SeaPerch, you will be adding the forces of your motors going forward, and the drag of the water going forward. If the force of the motor is greater than the drag of the water then the resultant force is in the direction of the motors's force, and your SeaPerch is accelerating. If the drag is greater than the force of your motor then the resultant force is in the direction of the drag and your Sea Perch will start to slow down. If the forces are exactly equal, this is called equilibrium, and your Sea Perch is resting or moving at a constant velocity.

In previous lessons, you have explored measuring different forces that act on your Sea Perch through the vectors and buoyancy lessons. In this activity, we will be constructing a test stand, so that we can *measure the thrust of each of the SeaPerch's motors in water.*

Introduction Questions:

1.) For your SeaPerch, what is the primary source of acceleration (*thrust*)? What is the main source of deceleration (*drag)?*

2.) Sketch a picture of your SeaPerch and show the force vectors that are acting on your Sea Perch in the horizontal direction (forward and backward). It is alright to estimate the numbers at this point.

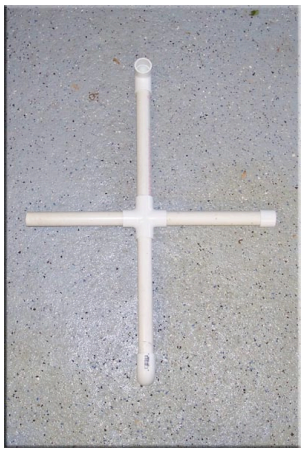
3.) Based on the numbers you chose, will your Sea Perch be accelerating or decelerating and with how much force in either direction? Explain your answer.

Experiment: Building your Thrust Test Stand

Materials needed:

•4 pieces of PVC piping (~ 8 - 12 “, should be of equal length, in SeaPerch kit)
•3 PVC caps that fit your piping (1/2” piping is included with your SeaPerch)
•1 PVC 4-way cross (1/2”)
•1 PVC elbow (1/2”, included in SeaPerch)
•Rubber bands or plastic ties
•Plastic storage container for water
•SeaPerch motor (ready for submersion), battery, and wires
•Digital Fishing Scale with hook (to measure thrust)
•Small hand saw, box cutter or other object for making cuts in the plastic container.

Procedure: Thrust Test Stand Construction



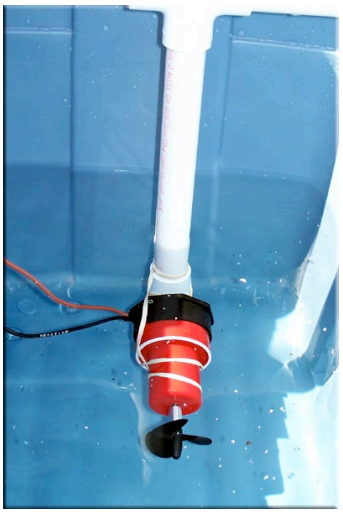
1.) Take your 4 pieces of PVC piping and attach them to the 4-way cross, making sure that the 2 vertical arms have exactly the same length. Attach the PVC caps to the 2 horizontal arms and the bottom are. Then, place the elbow on the top piece of piping.

2.) To hold the 2 horizontal arms in place you will need to make 2 cutouts on each side of the storage container. The cuts should be just wider than your PVC piping, and the depth of your cut should be slightly bigger than the piping, so it can comfortably rest in the cut-outs.

Make sure to mark your cuts before cutting and *be careful!!*

3.) Next, you are going to attach the Seaperch motor to the bottom of your test stand. You can do this using rubber bands or with the fasteners provided in the kit. You want to make sure that the motor is securely attached to the PVC piping.

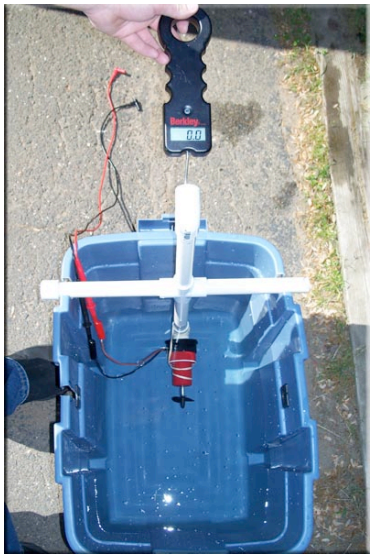
Once the motor is attached, place the test stand in the storage bin cut-outs. Fill the bin with water so that your motor is submerged.



4.) You will use the digital fishing scale to measure the force of the motor's thrust. In this case (depending on your scale), it will give you a reading in pounds.

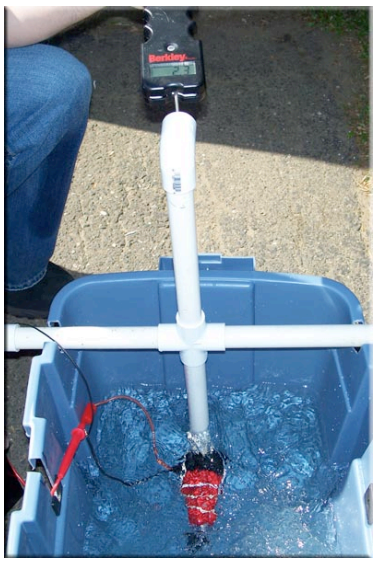
Take the hook that is on the end of the scale and secure it inside the top PVC elbow by placing the sharp end inside the elbow, curving down into the corner.

In a resting position, with the motor turned off the scale should read 0.0 lbs.



5.) The motor should be placed in the water such that the force is in the direction towards the fishing scale. Turn the motor on. As the bottom arm of the lever moves toward you, this force transfers to the top arm which pulls the scale's hook, giving you a measurement of thrust in pounds.

It is important while measuring not to pull back on the scale. Try your best to keep the scale steady and let the forces of your motor act independently on your test stand thrust measurement/s.



***Data Collection & Analysis Questions**:*

1.) When I measured the *thrust* of the SeaPerch motor, I found that the force was _____ lbs.

Repeat this process 2 more times to make sure you have a consistent measurement...

Trial 2 = _____lbs.

Trial 3 = _____lbs.

If the 3 measurements are not the same, compute the average thrust. _____

2.) The SeaPerch has 3 motors. Try repeating procedures #3-5 for the other 2 motors. Do you think they will have exactly the same thrust force? If not, what could be some sources of difference between the different motors / propellors you have built?

3.) **Motor 2 (thrust)** **Motor 3(thrust)**

Trial 1:

Trial 2:

Trial 3:

Once again, if measurements for each motor differed by trial find the average:

Motor 2 average thrust: _____

Motor 3 average thrust: _____

4.) Imagine that you have all 3 of your motors pointing in the same direction (forward). Write a vector equation (*use numbers and arrows)* to show the total force of forward thrust. (*Use the average thrust values if measurements varied).*

5.) Solve the equation:

Total Forward Thrust for 3 motors = _____lbs.

Next Steps and SeaPerch Connections

1.) We previously have learned that Force = Mass x Acceleration.

You have already calculated the total forward thrust if all three of your motors are active. If there is a 1.5 lbs. drag of water pushing against your Sea Perch, and the Sea Perch has a mass of 4 kilograms, figure out the following:

a.) What is the *resultant force* acting on the Sea Perch. Make sure to identify which horizontal direction it would move (*forward / back).*

b.) What is the acceleration of the SeaPerch? Use the equation above using your resultant force as Force.

2.) Think about the experiment we just did to measure thrust. How could we use the knowledge we have about vectors and measuring motion to figure out the force of the *drag* caused by the water on our SeaPerch?