A *JETSTREAM* with 1000 turns on its rubber motor will have an **average speed** around 4.6 m/s. The average speed of the plane should remain constant if the rubber motor has been pre-stretched. (See note below.) The speed remains the same because the *JETSTREAM* has no movable control surfaces (rudder, ailerons, elevators); the trim never changes and, in general, the plane flies at the same angle of attack. In addition, keeping the number of turns on the rubber motor constant also ensures that the average speed should remain constant for each flight.

According to **Newton's 1st law, inertia,** a plane at rest will remain at rest until a force acts on it. A plane with 1000 turns on the rubber motor will create the thrust necessary to accelerate the plane forward. Once the plane is in motion, it will stay in motion in a straight line until a force (like drag, gravity or the string) acts on it. If the pylon string were to break, the inertia of the plane would cause it to fly off in a straight line.

Centripetal force pulls the plane toward the center of the curved path. The pylon string applies the centripetal force and counteracts the inertia and velocity of the plane. The centripetal force causes the plane to change direction. In fact, centripetal force causes the plane to accelerate toward the center of the curved path.

The plane accelerates forward according to **Newton's Second Law, F=MA**. Acceleration is directly proportional to thrust. At liftoff, a plane with twice the thrust will accelerate twice as much and will takeoff sooner within a relatively short distance. Launching a plane with very little thrust will result in a small acceleration, which will require the plane to travel a greater distance around the pylon while its speed increases to the point at which it can lift off the ground.

Newton's 2nd law also predicts that a heavier plane with the same thrust will experience a smaller acceleration. Conversely, this law predicts that lighter planes with the same thrust will have a greater acceleration and will takeoff sooner.

Newton's 3rd law states that *forces come in pairs*. For instance, as the propeller spins and pushes air back, the air is pushing back with the same force. As a wing pushes air down, the air pushes upward with the same force. And according to Newton's 3rd Law, the pylon string and the plane pull with equal and opposite force.

When you wind the rubber motor of a model plane, you are storing **potential energy**. This energy is transformed into kinetic energy when you launch the plane. As the rubber motor of the plane unwinds, potential energy is transformed into **kinetic energy**, the energy of motion. Kinetic energy is expressed in the following ways: the propeller spinning, the air being pushed backwards, and the plane moving forward. As a plane flies upward, some of its kinetic energy is transformed into potential energy. When it descends, this potential energy is transformed back into kinetic energy.

Note: Average speed = distance/time. The average speed of the plane should remain constant if the rubber motor of the plane has been pre-stretched. However, if you do not stretch your motor before testing, you may notice that flight times will increase for each succeeding trial- thereby affecting your data.

Sample Data: The following table shows some likely results for a pylon plane with a radius of 2.1 meters:

Turns on the Rubber Motor	Liftoff Around Pylon	Average Laps	Average Distance	Average Seconds	Average Speed
1000	25%	5.84	77.02 meters	16.58 sec	4.64 meters/second

AEROLAB

AVERAGE SPEED

Name _____ Class Period _____

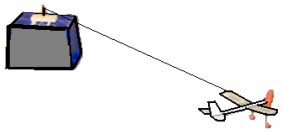
Background: Average speed is the distance traveled divided by an elapsed time. For instance, if you drive 100 miles in 2 hours, your average speed would be 50 miles/hour. Here is the formula for calculating average speed:

$$\textbf{Average Speed} = \frac{\textbf{Distance}}{\textbf{Time}}$$

Directions: You will be working in groups to determine the average speed of a *JETSTREAM*. Follow the steps below.

1) Calculate the distance your plane will fly around the pylon in one revolution:

The **radius** from the pylon to the fuselage = _____ meters.

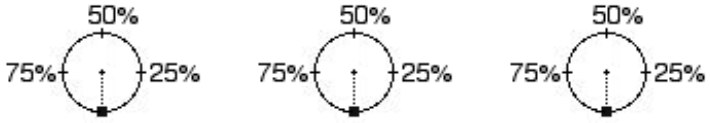


One lap = Circumference = $2\pi r$ = _____ meters.

2) After winding your plane 1000 times, release it and note the exact point of takeoff. Record the takeoff point on each circle below. (The release point of the plane is represented by the dot at the bottom of the circle.) Meanwhile, have another person in your group time how many seconds the plane flies in the air around the pylon while a third person counts the laps in the air. Stop timing and counting laps the instant the wheels of the plane touch down. Wind the rubber motor of the plane the same number of times for each trial.

3) Record your data in the table below:

LAPS AND FLIGHT TIME OF THE JETSTREAM			
Trial 1	**Trial 2**	**Trial 3**	**Averages**
Laps =	Laps =	Laps =	Average Laps =
Seconds =	Seconds =	Seconds =	Average Seconds =



Takeoff = ___ % Takeoff = ___ % Takeoff = ___ %

4) Calculate the average speed of your *JETSTREAM*.

$$\textbf{Average Speed} = \frac{\textbf{Distance}}{\textbf{Time}} = \frac{(\textbf{Average Laps} \times \textbf{Circumference})}{\textbf{Average Seconds}} = \_\_\_\_\_ \textbf{ m/sec}$$