When you wind the rubber motor of a model plane, you are storing **potential energy**. As the rubber motor of the plane unwinds, the 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.

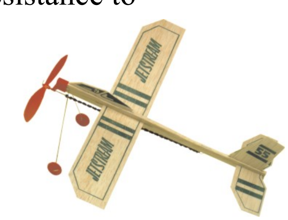
In general, according to **Newton's 2nd law, F=MA**, planes with more turns on the rubber motor will generate more thrust and will have a greater acceleration than planes with fewer turns. Acceleration is directly proportional to thrust. At liftoff, a plane with twice the thrust will accelerate twice 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.

A plane with more turns on the rubber motor will liftoff sooner; it will also fly faster, higher and farther than a plane with fewer turns. Planes with more turns on the rubber motor will also have longer flight times.

The pylon string applies centripetal force that counteracts the velocity and inertia of the plane. According to Newton's 3rd Law, the string and the plane pull with equal and opposite force. If the pylon string were to break, the inertia of the plane would cause it to fly off in a straight line.

According to **Newton's 3rd law**, every force has an opposing force. As the propeller pushes air back, the air pushes the propeller and plane forward with equal force. The wing pushes air down and the air pushes the wing upward with equal force.

As thrust accelerates the plane forward, the wings of the plane generate lift. Drag, the resistance to forward motion, is a by-product of the plane's passage through the air. As the plane accelerates, drag increases until the drag equals thrust, causing the plane to fly at constant speed. At this point lift also equals weight.

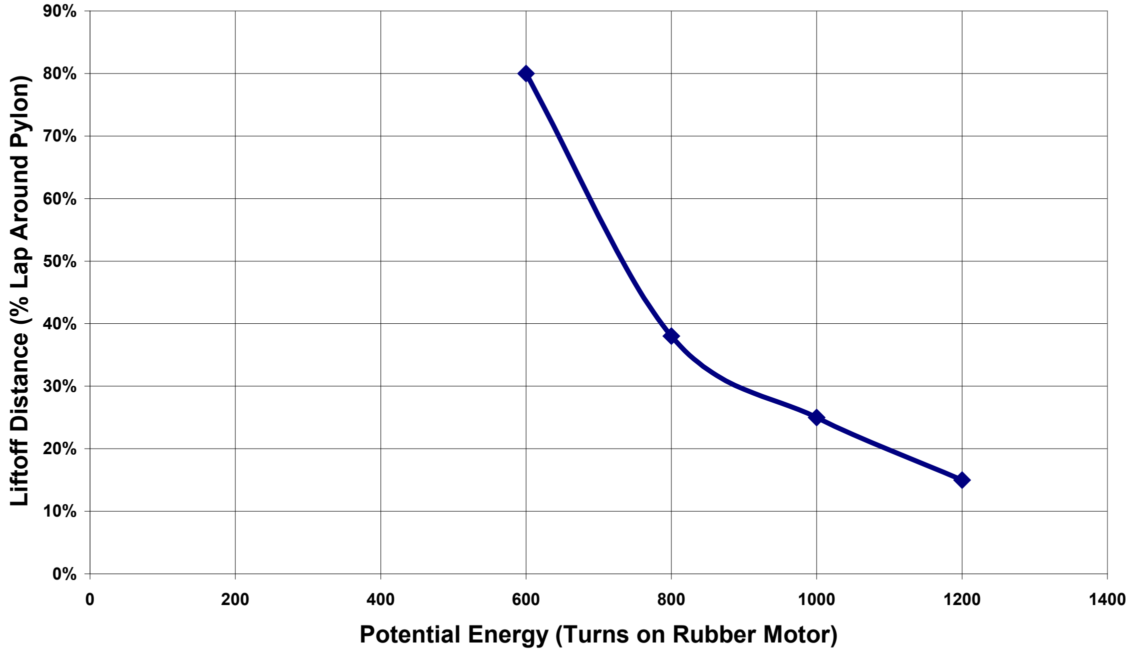


Sample Data: The following table shows some likely results for a pylon plane with a radius of 2.1 meters:

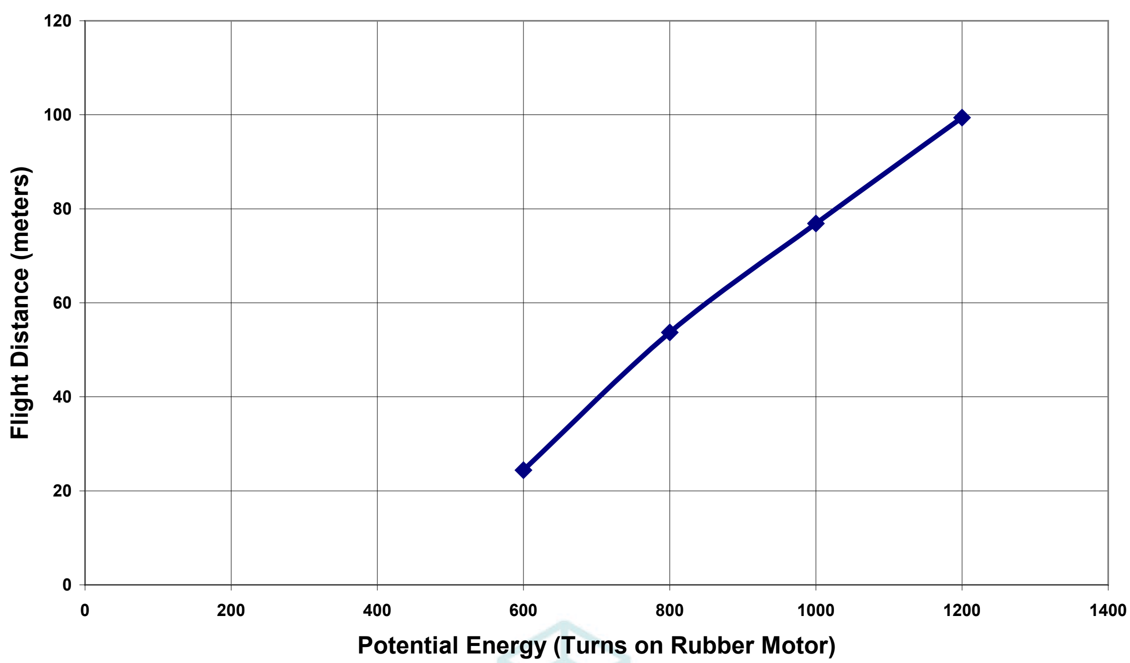
Turns on the Rubber Motor	Liftoff Around Pylon	Average Laps	Average Distance	Average Seconds	Average Speed
600	80%	1.85	24.40 meters	5.68 sec	4.30 meters/second
800	38%	4.07	53.68 meters	11.89 sec	4.51 meters/second
1000	25%	5.84	77.02 meters	16.58 sec	4.64 meters/second
1200	15%	7.53	99.32 meters	20.27 sec	4.90 meters/second

See the graphs on the next two pages.

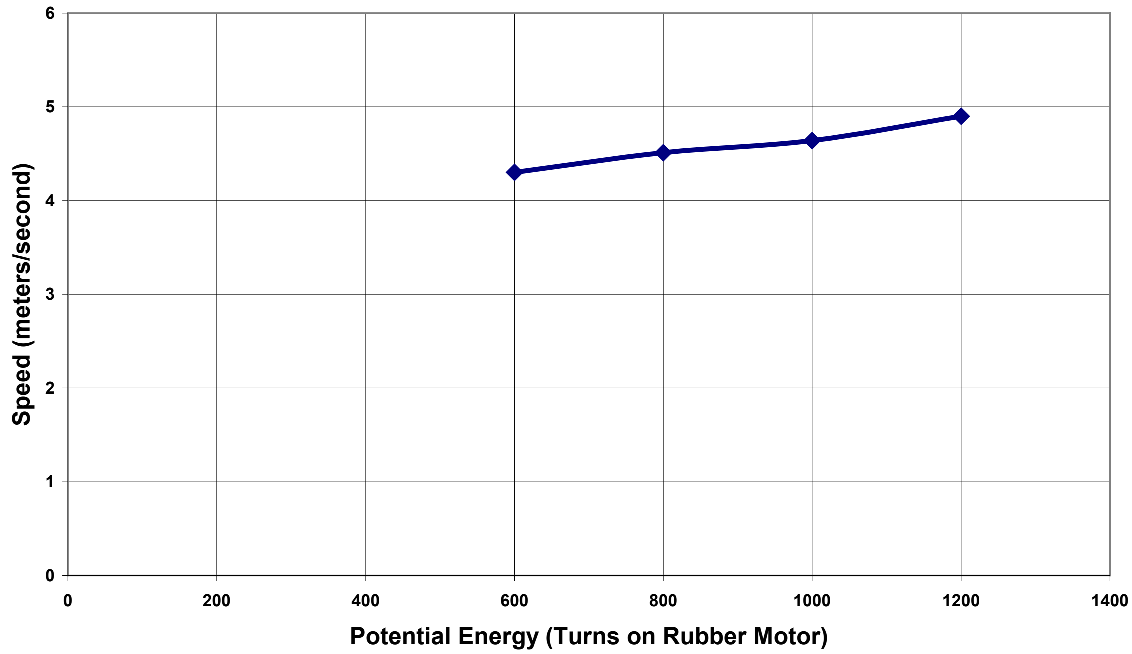
Effect of Potential Energy on Liftoff Distance



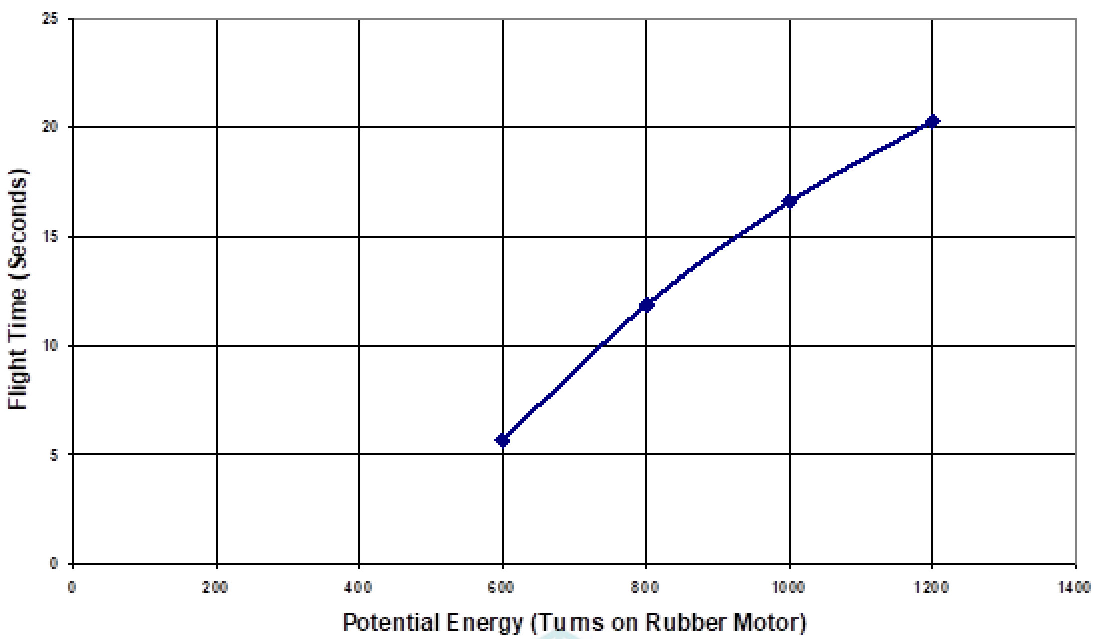
Effect of Potential Energy on Flight Distance



Effect of Potential Energy on Speed



Effect of Potential Energy on Flight Time



Name ____ Class Period _____

Background: 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. In general, according to Newton's 2nd law, F=MA, planes with more turns on the rubber motor will generate more thrust and accelerate faster than planes with less thrust. As thrust accelerates the plane forward, the wings of the plane generate lift. Drag, the resistance to forward motion, is a by-product of the plane's passage through the air. As the plane accelerates, drag increases until the drag equals thrust, causing the plane to fly at constant speed. At this point lift also equals weight. Planes with more potential energy will generate more thrust and will fly farther and faster.

Directions: You will study how increasing the turns in a rubber motor will affect a plane's average speed and flight distance. Work with your partner or group and choose one plane to study.

1) Finish this hypothesis: If thrust increases, then…

2-4) List at least three variables you should keep the same every time you test your plane.

5) The radius from the pylon to the fuselage = ________ meters

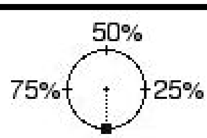
6) One revolution = Circumference = $2\pi r$ = __________ meters

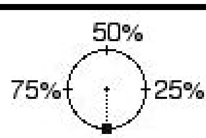
7) Flying your *JETSTSREAM* with 600 turns on the rubber motor:

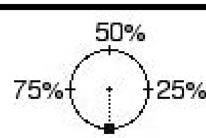
- Move your wing to balance your plane. Mark the wing position with a pen. Use a winder to put 600 turns on your rubber motor.

- Release your plane 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.

JETSTREAM WITH 600 TURNS ON THE RUBBER MOTOR			
Trial 1	**Trial 2**	**Trial 3**	**Averages**
Laps =	Laps =	Laps =	Average Laps =
Seconds =	Seconds =	Seconds =	Average Seconds =





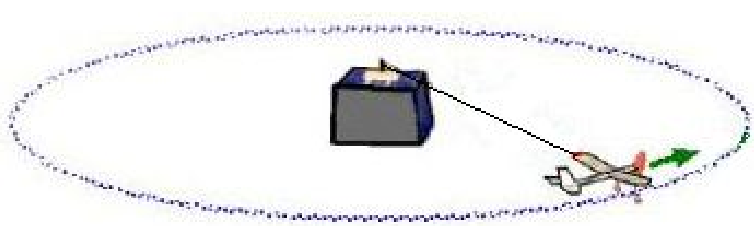


Takeoff = ___% Takeoff = ___% Takeoff = ___%

8) **Distance Plane Flew with 600 Turns = Average Laps x Circumference = ___________ m**

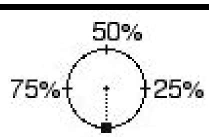
9) Calculate the average speed of your *JETSTREAM* with 600 turns:

$$\textbf{Average Speed} = \frac{\textbf{Distance}}{\textbf{Time}} = \frac{\textbf{Distance Plane Flew}}{\textbf{Average Seconds}} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \ \textbf{m/sec}$$

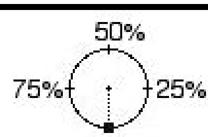


10) Flying your *JETSTSREAM* with 800 turns on the rubber motor:
- Move your wing to the mark. Use a winder to put 800 turns on your rubber motor.
- Collect data using the same procedure as before.

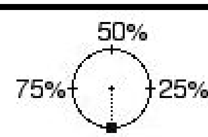
JETSTREAM WITH 800 TURNS ON THE RUBBER MOTOR			
Trial 1	**Trial 2**	**Trial 3**	**Averages**
Laps =	Laps =	Laps =	Average Laps =
Seconds =	Seconds =	Seconds =	Average Seconds =



Takeoff = ___%



Takeoff = ___%



Takeoff = ___%

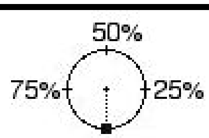
11) **Distance Plane Flew with 800 Turns = Average Laps x Circumference = ___________ m**

12) Calculate the average speed of your *JETSTREAM* with 800 turns:

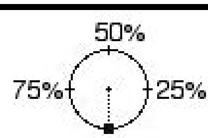
Average Speed = $\frac{\textbf{Distance}}{\textbf{Time}}$ **=** $\frac{\textbf{Distance Plane Flew}}{\textbf{Average Seconds}}$ **= _______________ m/sec**

13) Flying your *JETSTSREAM* with 1000 turns on the rubber motor:
- Move your wing to the mark. Use a winder to put 1000 turns on your rubber motor.
- Collect data using the same procedure as before.

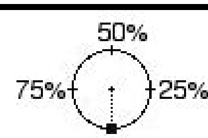
JETSTREAM WITH 1000 TURNS ON THE RUBBER MOTOR			
Trial 1	**Trial 2**	**Trial 3**	**Averages**
Laps =	Laps =	Laps =	Average Laps =
Seconds =	Seconds =	Seconds =	Average Seconds =



Takeoff = ___%



Takeoff = ___%



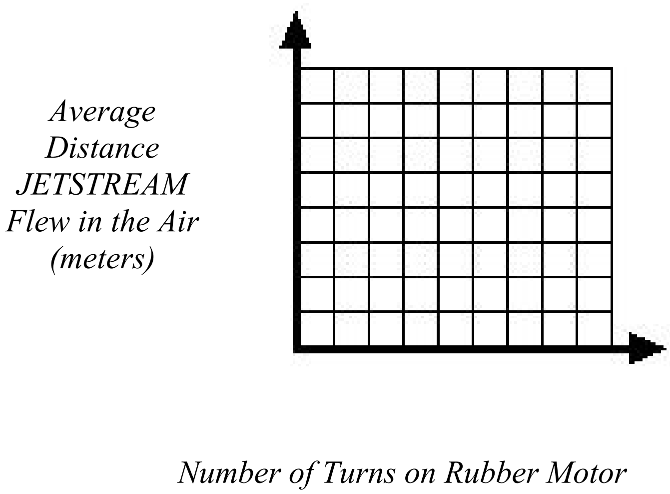
Takeoff = ___%

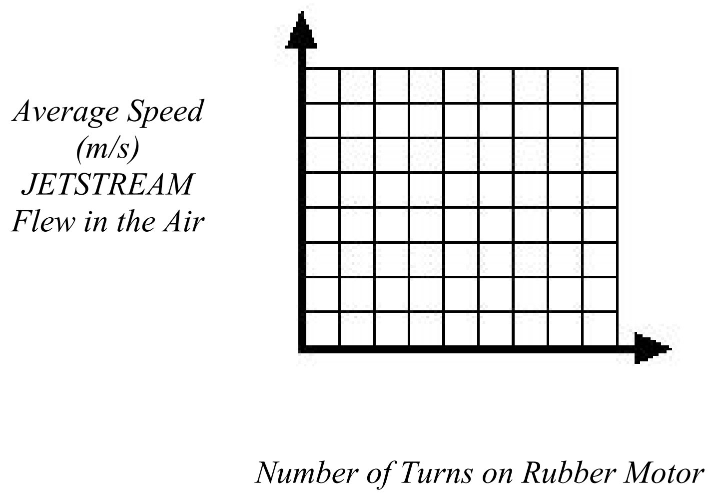
14) **Distance Plane Flew with 1000 Turns = Average Laps x Circumference = ___________ m**

15) Calculate the average speed of your *JETSTREAM* with 1000 turns:

Average Speed = $\frac{\textbf{Distance}}{\textbf{Time}}$ = $\frac{\textbf{Distance Plane Flew}}{\textbf{Average Seconds}}$ = **_______________ m/sec**

16) Graph your data:





17) How did changing the number of turns on the rubber motor affect the takeoff distance?

18) How did changing the number of turns on the rubber motor affect the average distance flown?

19) How did changing the number of turns on the rubber motor affect the average speed of the plane?