Full:

For this experiment, you will need several materials: a large cardboard box (enough to cut into two pieces of 160 cm in length and 60 cm in width), duct tape, a hot glue gun with approximately 20 glue sticks, a digital anemometer, a leaf blower, balsa wood or 3D printed plastic for wing supports, two dowel rods (diameters: 0.8 cm and 1.4 cm), foam board (45 cm x 35 cm), two DC motors, a multimeter, wind turbine blades (two for each design to be tested), a marker, a ruler, and a utility knife.

The procedure begins with the construction of the wind tunnel. Start by cutting the large cardboard box into two pieces, each measuring 120 cm in length and 55 cm in width. Score these pieces lengthwise every 30 cm to allow them to bend easily. Wrap the pieces around to form a rectangular tunnel, securing the seams with duct tape and filling any cracks, especially the scoring seams, with hot glue. At one end of the tunnel, mount the leaf blower by cutting a gap in a piece of cardboard where the nose of the leaf blower can fit. Use duct tape and hot glue to secure the blower into the gap, ensuring it is positioned to direct airflow into the tunnel. Attach this assembly to the tunnel walls using hot glue and duct tape, and make sure to construct a small cardboard stool to support the leaf blower's body, leaving enough space for the fan to collect air. Seal any seams or gaps with duct tape and hot glue to ensure there are no leaks and to maintain a consistent airflow. After completing the tunnel, test the airflow by turning on the leaf blower and measuring the wind speed with the digital anemometer. Adjust the wind speed to approximately 55 kph

Next, construct the wing structure. Using thin wood or foam board, replicate the NACA 6412 Airfoil design, scaled to a length of about 40 cm. Create four supports and drill four holes in each of the front, middle, and back sections to reduce weight and create space for wire routing. Use hot glue to place spare wood or foam board pieces between the supports for added bracing. Then, score two pieces of foam board, each measuring 41 cm by 20 cm, at intervals of 0.25 cm for the first 4 cm and 1.5 cm for the remainder. This scoring will allow the foam board to wrap around the airfoil design easily. Attach the foam board pieces to the supports, ensuring a 4 cm gap between each support and a 12 cm gap in the middle. Secure the foam board to the supports with hot glue, reinforcing joints with additional tape and glue. Trim any excess material and sand rough edges for a smooth finish.

Now, create a 7 cm x 6 cm gap at the bottom of the wing, 9 cm from the bottom and 6.5 cm from the edge. Drill a hole 12 cm from the bottom of the wing, equally spaced between the two edges, which will accommodate the metal rod of the DC motor. Insert the DC motor through this gap with the metal rod facing outward and route the connection wires using electrical tape through the second hole from the bottom of the supports. Connect the wires to the multimeter and reattach the cut-out section of the wing using tape. Next, attach the Savonius wind turbine blades to the motor and test them. Repeat this process for the H-Rotor wind turbine by removing the DC motor and wind turbine blades, ensuring the cut-out portion of the wing is reattached. For the Parallel to Wind wind turbine, cut a 5 cm x 2.5 cm gap on the top of the wing, starting 9.5 cm from the bottom and 9 cm from one edge. Attach the DC motor sideways, facing inward, to this gap, and connect it to the turbine as before. Test the Parallel to Wind wind turbine using the same procedure, then remove the DC motor and fill in the cut-out section of the wing. For the Horizontal-Axis wind turbine, cut a 2 cm x 2 cm box in the front curved portion of the wing, 9 cm from one edge. Attach the DC motor sticking outward into the gap, ensuring the wires are routed through the second forward-most hole in the supports before gluing the motor in place. Secure the wires with electrical tape and connect them to the multimeter. Attach the Horizontal-Axis wind turbine to the motor and test it following the same procedure.

To connect the wing to the wind tunnel, use dowels that fit snugly in the farthest forward and back holes of the wing supports, and insert these dowels through the outside of the wind tunnel. Align the wing in the center of the tunnel to capture the maximum airflow from the leaf blower. Set the multimeter to the 20V reading mode. Carefully place the completed wing model inside the wind tunnel, ensuring the turbines are aligned to face the incoming airflow. Activate the fan and use the anemometer to ensure the wind speed is approximately 55 kph. If the wind turbine does not automatically spin, give it a small spin to start it. If it still does not spin, leave it alone and take a multimeter reading. Connect the multimeter to each DC motor to measure the electrical output during the airflow, recording the output for each motor. Analyze the efficiencies of each wind turbine design by comparing the calculated power outputs, and document the data for each design tested. Refer to the previous paragraph for more detailed instructions on how to conduct the wind turbine testing.

Report Style:

This experiment investigated the effect of different wind turbine blade designs on the power output of wing-integrated wind turbines (WIWTs). Materials used included a large cardboard box (cut into two panels measuring 160 cm × 60 cm), duct tape, a hot glue gun with approximately twenty glue sticks, a digital anemometer, a leaf blower, balsa wood or 3D-printed plastic for wing supports, two wooden dowels (0.8 cm and 1.4 cm diameters), foam board sheets (45 cm × 35 cm), two DC motors, a multimeter, and multiple wind turbine blade sets (two blades per design). Additional tools included a marker, ruler, and utility knife.

The wind tunnel was constructed by cutting the cardboard box into two panels, each measuring 120 cm × 55 cm. Panels were scored every 30 cm to facilitate bending and were then formed into a rectangular tunnel. Seams and scored areas were secured with duct tape and reinforced with hot glue to prevent air leakage. A mounting system for the leaf blower was created by cutting a gap in a separate cardboard panel to fit the blower's nose. The blower was inserted, secured with tape and glue, and supported with a small cardboard stool to maintain clearance for airflow. After construction, the wind tunnel airflow was tested using the digital anemometer, and the leaf blower was adjusted to produce a wind speed of approximately 55 kph.

The wing structure was built using thin wood or foam board to replicate a NACA 6412 airfoil, scaled to a length of 40 cm. Four internal supports were created, each drilled with four holes at the front, middle, and back to reduce weight and allow for wire routing. Additional foam board or wood pieces were glued between supports to strengthen the structure. Two foam board sheets (41 cm × 20 cm) were scored at 0.25 cm intervals along the first 4 cm and 1.5 cm intervals for the remainder to allow them to bend around the airfoil. The scored sheets were glued to the supports, leaving 4 cm between each support and a 12 cm gap at the center. Excess material was trimmed, and edges were smoothed with sanding.

Openings were cut into the wing to install each turbine type. For the Savonius configuration, a 7 cm × 6 cm opening was cut at the bottom of the wing and a round hole was drilled to accommodate the DC motor shaft. The motor was inserted with the shaft facing outward, and wires were routed through the support holes and connected to the multimeter. The turbine blades were attached, and preliminary tests were conducted. The H-Rotor and Horizontal-Axis turbines were installed using similar procedures, with corresponding openings cut in the wing and motors and blades mounted according to their orientation. For the Parallel-to-Wind turbine, a 5 cm × 2.5 cm slot was cut on top of the wing, the motor was mounted sideways with the shaft facing inward, and the turbine was attached and tested.

The completed wing was mounted inside the wind tunnel using wooden dowels through the farthest forward and rear holes in the supports. The wing was positioned in the center of the tunnel to maximize airflow exposure, and the multimeter was set to the 20V DC setting. The leaf blower was activated, and wind speed was confirmed at approximately 55 kph using the anemometer. If a turbine did not spin automatically, it was manually started before taking readings. Electrical output from each turbine was recorded for five trials per design, and the data were analyzed to determine power generation efficiency. All procedures were repeated consistently to ensure reliable comparisons between turbine designs.