<u>Mandatory 3</u>: Lab Practicum – [10 pts possible]

Lab Practicum Choice 1: Aeronautics for Introductory Physics

Using the Aeronautics for Introductory Physics guide, select one hands-on, lab-based activity that teaches concepts of force and motion. Perform the activity either on your own or with students. You may implement it as written or make modifications that are appropriate to your students. In any medium you choose (i.e. document, presentation slides, digital poster, or video), include the following criteria in the rubric below.

Criteria	Possible Points	Meets Criteria
Lab Experience	5	• Provides brief overview of the chosen lab. • Includes series of photographs/screenshots or video that document that you completed the activity in full and/or had your students complete the activity. • Demonstrates sample student work (either from your or students) showing authentic observations, data, and a conclusion (or outcomes as appropriate to the assignment).
Teacher Reflection	5	• Describes how the activity connects to physics learning outcomes. • Reflects on the pros/cons and age/development appropriateness of the activity to your own students.

Lab Title: Literary/Data Analysis: Wings According to Size

Overview: This laboratory introduces the aeronautic concept of wing sizes and lift. It utilizes a combination of scientific text and diagrams to teach the content. It also involves a bit of mathematical reasoning based on equations.

Rationale: I chose this lab because data analysis is a critical skill in my class. We are constantly interpreting a variety of diagrams (mostly related to Earth Science). I was curious if I could utilize graphs or elements from this lab in my unit on forces and motion. The subsequent slides show my attempt to complete this lab from a learner's perspective. All my responses are written in green.

Note: There was an answer key in the original PDF, but I chose not to consult it until after I had completed the work on my own. There were times when I wanted to look at an exemplar answer because I was confused, but I fought back the temptation.

Task: Read The Simple Science of Flight, chapter 1: Wings According to Size.

1) Based on the first two pages of the chapter, how is "**carrying capacity**" of an airplane (or any other object) calculated?

   My answer: The carrying capacity of an airplane is calculated by dividing its **total weight** (weight of plane + anything that it is carrying) by its **surface area.**

2) Performance can also be measured by fuel consumption. What variables do you think influence fuel consumption of any moving object?

   My answer: Some variables that can influence fuel consumption include weight of the plane, fuel quality (or type of fuel used), speed at which the plane is moving, and acceleration.

Task: The author identifies four factors that influence the lift of an airplane or flying bird. Complete the chart below.

Factors	Symbols	Unit	Why does it influence lift?
Air Density	*p*	kg/m^3	Since mass flow is proportional to air density, the higher the density the greater the mass flow.
Air Speed	V	m/s	Air speed is also proportional to mass flow. The higher the air speed, the more air that can be deflected downward to increase lift.
Wing area	S	m^2	Wing area is proportional to mass flow and lift. The greater the wing area, the more surface area there is to interact with air particles to create lift. However, its proportion to the weight of the flying object also affects the lift.
Angle of attack of wing	*a*	degree	Changing the angle of attack can result in an increase or decrease in air resistance, thus impacting lift. At higher angle of attack, drag increases. Angle of attack also needs to be reduced to support a greater weight or during a turn.

Task: Lift, Weight, and Speed

4) How must lift (L) compare to weight (W) in order for an object to cruise at a constant altitude? Why?

   My answer: Lift must be equal to weight in order for an object to cruise at a constant altitude, because the amount of lift and the force of gravity acting on the object would balance out.

Task: Wing Loading

Wing Loading

Look at Table 1, reproduced here to the right, to answer the following questions:

5. What is the general trend between a bird's weight and the speed it needs to be able to cruise?

The higher a bird's weight, the faster it needs to fly in order to cruise.

6. This table shows data for various seabirds. How would you expect the data in each column to change if this table showed, instead, non-migrating backyard songbirds? Why?

All columns would have lower value, because songbirds are much smaller and since they do not need to fly as fast, their wings are most likely smaller.

7. How would the data from your lab experience with the paper planes compare?

I did not do the paper plane lab.

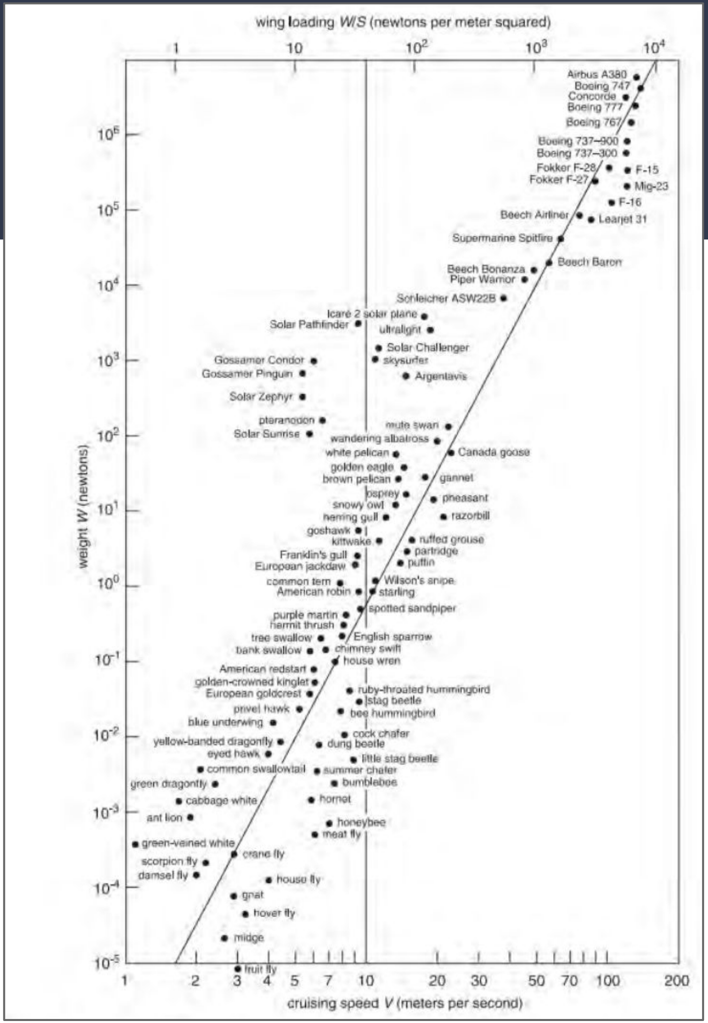
Table 1 Weight, wing area, wing loading, and airspeeds for various seabirds, with *W* given in newtons (10 newtons = 1 kilogram, roughly), *S* in square meters, and *V* in meters per second and miles per hour. The values of *W* and *S* are based on measurements; those for *V* were calculated from equation 2. In general, larger birds have to fly faster.

				V	
	W	*S*	*W/S*	m/sec	mph
Common tern	1.15	0.050	23	7.8	18
Dove prion	1.70	0.046	37	9.9	22
Black-headed gull	2.30	0.075	31	9.0	20
Black skimmer	3.00	0.089	34	9.4	21
Common gull	3.67	0.115	32	9.2	21
Kittiwake	3.90	0.101	39	10.1	23
Royal tern	4.70	0.108	44	10.7	24
Fulmar	8.20	0.124	66	13.2	30
Herring gull	9.40	0.181	52	11.7	26
Great skua	13.5	0.214	63	12.9	29
Great black-billed gull	19.2	0.272	71	13.6	31
Sooty albatross	28.0	0.340	82	14.7	33
Black-browed albatross	38.0	0.360	106	16.7	38
Wandering albatross	87.0	0.620	140	19.2	43

Task: Wing Loading

8) Describe the relationship between weight and wing loading for these seabirds. Why do you think this trend is present?

My answer: The ratio of weight to wing loading for seabirds is much higher when the bird weighs less. It might be the heavier the bird, the stronger its body structure must be to support the weight, which also adds to the total weight and influences the wing load.



Task: Wing Loading

9)

Equation	What does it mean?	How is it different from others?
$W = 0.3pV^2S$	Weight is proportional to air density, air speed, and wing area	This equation models the proportion of the weight of a bird/plane to the air density, speed, and wing area.
$W/S = 0.38V^2$	Wing loading is proportional to the speed squared.	This equation explains the relationship between speed and wing load.
$W/S = c \times W^{1/3}$	Wing loading is proportional to the weight raised to the ⅓ power times a coefficient	This equation explains the relationship between the weight of a bird and its wing load.

Note: I still find these equations and variables to be confusing. I wish there were diagrams in the reading to illustrate what each means. My students would also benefit from having visual diagrams to go with the reading.

Task: Lift, Weight, and Speed

10) What is the meaning of the vertical line on the graph? What can you infer about birds/planes to the left or to the right of the vertical line?

My answer: The vertical line represents a speed of 10 m/s. I am still confused how they answer key states that this line represents the wind speed, but I guess it is showing the relationship between weight and wing load at this particular air speed. I suppose the data would change if the air speed picks up on a windier day?

Task: Lift, Weight, and Speed

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12) Where is Equation (3) visibly represented on the graph?

My answer: Is equation 3 the various plots on the graph? I say this because the variables on the axes match the variables in equation 3.

Task: Lift, Weight, and Speed

13) Given what you know about the vertical line and the angled line on the graph, compare the following flying objects' capabilities. How are they different?

Boeing 747	This plane is larger and carries more passenger, which contributes to a greater weight. I would assume it would need to fly at a greater speed to cruise at a constant speed. It would need to fly much faster than the wind speed as well.
Pteradon	A pteradon can cruise at constant speed slower than the wind speed, maybe that is due to its weight, which ranges from 20 to 93 kg, so it doesn't need as high of a speed to cruise.
Human-powered Airplane	A human-powered airplane is much smaller than a Boeing, and bigger than a Pteradon. It probably needs to fly faster than a Pteradon, and most likely wind speed as well, in order to cruise at constant speed.

Task: Lift, Weight, and Speed

14) Likewise, compare a crane fly, spotted sandpiper, and Beech King airplane. How are they different? (Compare weight, wing loading, and cruising speed). How are they similar?

My answer: Crane fly is the lightest out of all of them, followed by spotted sandpiper, then Beech King airplane. The cruising speed increases with their weight, so crane fly has the lowest cruising speed. Wing loading is also proportional to their weight as well. These 3 things are similar because all 3 fall on the angled line.

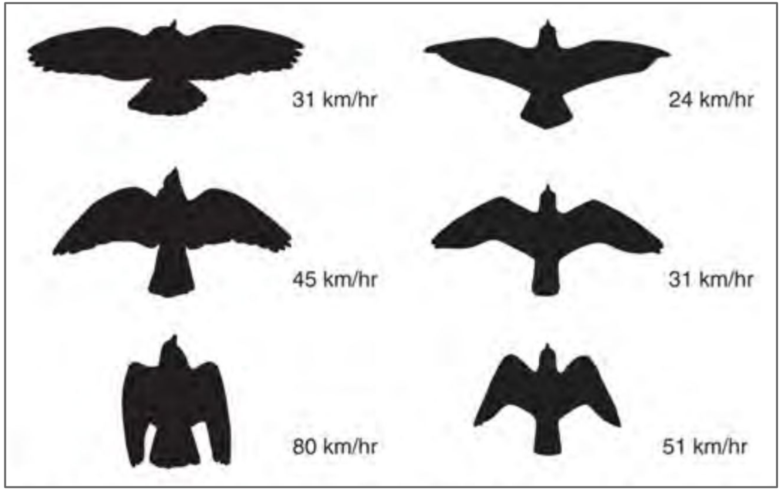
15) Based upon the graph and the information presented in the text, explain one of the reasons why the Concorde is now out of commission.

My answer: Concorde has too big of a wing span due to the constraints of the runway it takes off from and lands on. The text states that the Concorde needs to fly in the stratosphere where air density is lower as a result of its larger wingspan. However, conditions are more ideal in the troposphere.The large wing span most likely adds a lot of weight to the concorde, affecting its wingload.

Task: Lift, Weight, and Speed

16) What do birds do to modify their wings for various stages of flight? (Takeoff, cruising, landing). Why is this so important?

My answer: Birds modify their wings to increase or reduce drag and to change the angle of attack to deflect the air in the direction that would help them ascend or descend. When birds fold their wings, they become more streamlined, so they can fly faster to help them reach cruising speed. WHen they land, they probably want to open up their wings to create more drag and angle in a way that pushes air up instead of down to descend.



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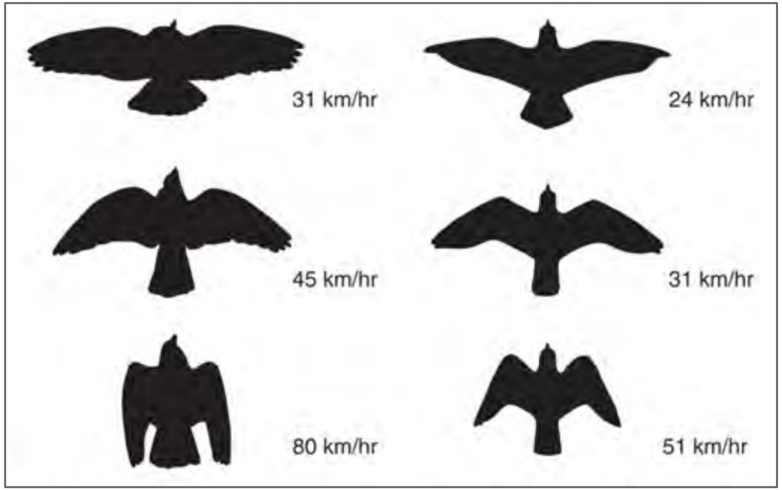

Reflection: Connection to Physics Learning Outcomes

One of the most fundamental concepts in my unit on forces and motion is that unbalanced forces result in a change in motion, while balanced forces maintain a steady motion (or lack of motion).

We can see the same concept in play when it comes to flight. In order for an object or bird to reach a constant cruising speed, it needs to balance between the forces of gravity and lift. Too much of a lift would result in an unbalanced upward force, which is desirable during take off. Too little of a life would result in an unbalanced downward force, which results in a descent.

What makes the phenomenon more complex is the consideration of other factors such as wing shape, angle of attack, and aerodynamics.

Reflection: Pros and Cons

Pros	Cons
• The real-world application makes this learning experience more authentic for my students. We can observe photos of a variety of planes and flying animals to make some inferences before diving into the complex physics behind it. • It allows my students to apply what they know about forces and motion to a scenario. Even if they cannot fully understand the different variables (ex: wing load, air density), they can still grasp what makes an airplane stay in the air.	• The text is very long and too high level for my middle school students. Some of the examples given might not be familiar to all my students. Having visual images of the planes or birds can be helpful. • I wish there were more diagrams to illustrate the different variables presented. I had a difficult time making sense of these variables myself, so I cannot imagine the struggle my students would go through. • The graphs are really tiny and blurry. I would probably enlarge it, or have students practice plotting it from a data set. • The questions were very challenging. I would need to modify it for my students.