Inspiring Greatness

INDEPENDENCE SCHOOL DISTRICT

Virtual Learning

Physics

Newton's Laws of Motion and Air Drag

April 28, 2020

Physics

Newton's Laws of Motion and Air Drag: April 28,2020

Objective/Learning Target:

Students will examine Newton's Laws of Motion and Air Drag.

Quick Review #1

While redecorating her apartment, Sandy slowly pushes an 96-kg refrigerator across the wooden kitchen floor, which resists the motion with a force of friction of 410 N.

What is the coefficient of sliding friction between the refrigerator and the floor?

Quick Review #1 Answer

The normal force is equivalent to the weight of the china cabinet because the cabinet is sitting on a horizontal surface.

So.. $F_W = mg$

$F_W = mg \quad (96\text{ kg})(9.8\text{ m/s}^2) = 941\text{ N}$

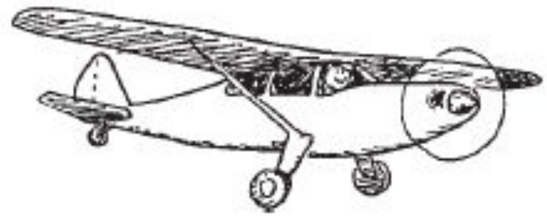
so F_N is also 941 N.

$F_f = \mu F_N$

$$\mu = \frac{F_f}{F_N} = \frac{410\text{ N}}{941\text{N}} = 0.44$$

Quick Review #2

An airplane makes a straight back and forth round trip, always at the same airspeed between two cities. If it encounters a mild steady tailwind going and the same steady headwind returning, will the round trip take more, less, or the same time a with no wind?



Quick Review #2 Answer

The windy trip will take more time. Here is an example.

Suppose the cities are 600 km apart, and the airspeed of the plane is 300 km/h (relative to still air). Then time each way with no wind is 2 hours. Round-trip time is 4 hours.

Consider a 100 km/h tailwind going, so groundspeed is (300 +100) km/h.

Then the time is $\frac{600 \text{ km}}{400 \text{ km/h}}$ = 1 hour and 30 minutes.

Returning groundspeed is (300-100) km/h and the time is $\frac{600 \text{ km}}{200 \text{ km/h}}$ = 3 hours

The windy round trip takes 4.5 hours, which is longer than with no wind at all.

Problem Solving Using Newton's Laws

Link: [Drag Forces]

Directions:

- Read through the section on Drag Forces.
- Work through any examples on a separate piece of paper before you scroll down to the solution.
- On a separate piece of paper complete the practice problems on the following slides.
- Check your answers.
- For additional practice check out the conceptual questions and the problems and exercises in the table of contents for the online text linked above.

Practice Problems

1. Determine the drag coefficient of a 75 kg skydiver with a projected area of 0.33 m² and a terminal velocity of 60 m/s.

2. By how much would the skydiver need to reduce her projected area so as to double her terminal velocity?

3. How would she accomplish this?

Practice problem #1 Answer

When air drag equals her weight the sky diver will have reached terminal velocity.

m= mass, g = gravity, *p* = density of air, A = surface area, v = velocity

So…

$mg = \frac{1}{2} p C A v^2$ rearranging for C - drag coefficient

$$C = \frac{2mg}{pAv^2} = \frac{2(75\text{kg})(9.8\text{m/s}^2)}{(1.21\text{ kg/m}^3)(0.33\text{ m}^2)(55\text{ m/s})^2} = 1.22$$

Practice Problem #2 Answer

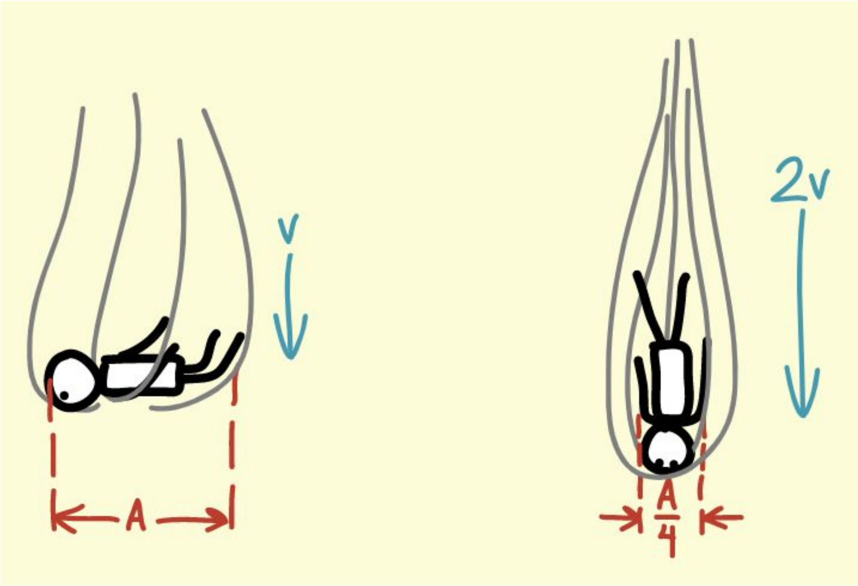
Don’t plug in any numbers, just look at the way terminal velocity is related to projected area. Projected area is in the denominator, under a radical sign. That means terminal velocity is inversely proportional to the square root of projected area. That means the skydiver would have to reduce her projected area to one-quarter of its original value.

$$v_t = \sqrt{\frac{2mg}{\rho C A}}.$$

$$2v_t \propto \sqrt{\frac{1}{\frac{1}{4}A}} \quad \Leftarrow \quad v_t \propto \sqrt{\frac{1}{A}}$$

Practice Problem #3 Answer

The skydiver can do this by changing her orientation from horizontal to vertical, basically from spread eagle to head first.



Additional Practice

For additional practice check out the conceptual questions and the problems and exercises in the table of contents from the online text linked above.