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Physics 200 (Stapleton) Name: *Key*

Ch. 5.1: Drag and Terminal Velocity

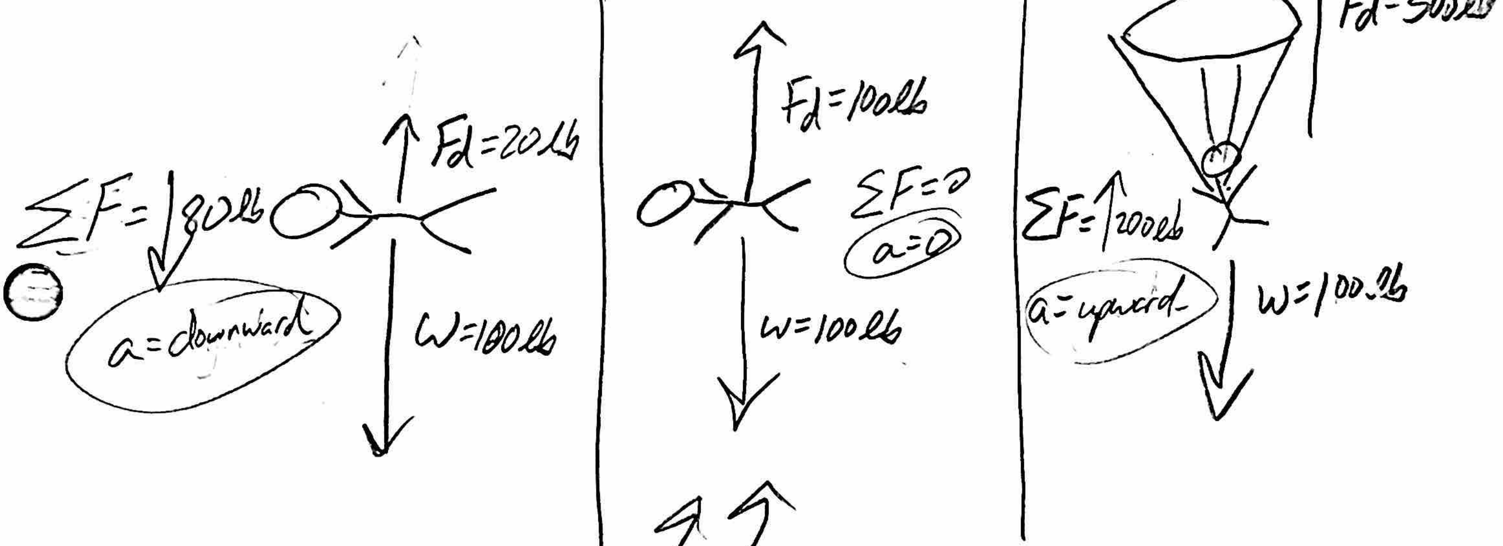
1. Drag force: *The force of friction acting on a body moving through a fluid* (fluid ← gas or Liquid)

2. Drag force equation:

$$F_d = \frac{1}{2} A C_d \rho v^2$$

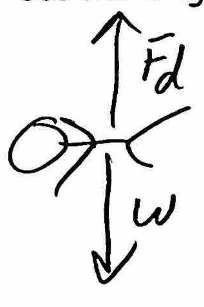
A ← Cross-sectional Area; ρ ← density of fluid; v ← velocity; C_d ← Drag Coefficient (aerodynamics)

3. Draw diagrams showing all of the forces acting on a skydiver in 3 different situations: negative acceleration, zero acceleration, and positive acceleration.



4. When a falling skydiver's net force and acceleration are zero, she or he is said to be at *terminal velocity*

5. Use the drag formula an equation for the terminal velocity of a skydiver.



at T.V. ⇒ $W = F_d$

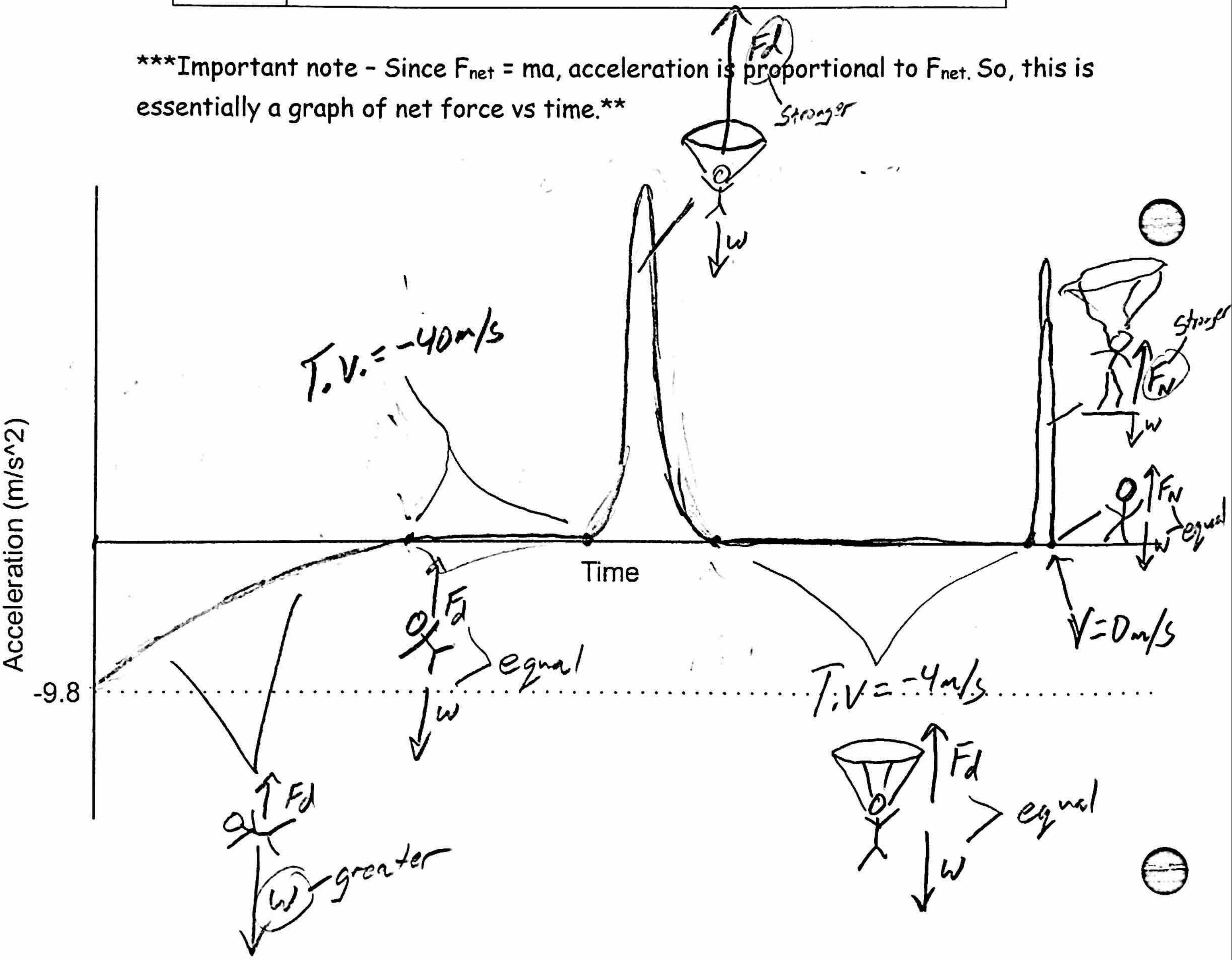
$$mg = \frac{1}{2} A C_d \rho v^2$$

$$\frac{2mg}{A C_d \rho} = v^2 \Rightarrow V_{terminal} = \sqrt{\frac{2mg}{A C_d \rho}}$$

6. The table below describes the experience of a skydiver who steps out of a stationary helicopter. Create a reasonable acceleration graph portraying this sequence of events. Note the skydiver's velocities at various points.

Sequence	Event
1	Skydiver steps off of helicopter
2	Skydiver reaches a **terminal velocity of -40m/s**
3	Skydiver pulls chute cord. Parachute deploys.
4	Skydiver reaches a new **terminal velocity of -4m/s**
5	Skydiver feet touch down
6	Skydiver comes to rest

***Important note - Since $F_{net} = ma$, acceleration is proportional to $F_{net.}$ So, this is essentially a graph of net force vs time.**



Conceptual Practice with Drag:

1. Consider a golf ball that is being dropped by an astronaut who is standing on the Moon. Gravity causes the ball the fall to the Moon's surface. Describe the action and reaction forces that are involved as the ball is falling toward the moon's surface.

Action: Moon pulls ball downward

Reaction: Ball pulls Moon upward

2. You're floating freely in outer space, and you have two seemingly identical boxes – box A and box B. Although the boxes look the same, one has much more mass than the other. Describe a test you could conduct in order to figure out which box has more mass, and explain how the results of the test would be different for the two boxes.

Push them. The more massive one is the box that
- resists your push more (more inertia)
- pushes you backward more

3. A small child and a team of Austrian weightlifters are fighting over a sturdy (though massless) scarf. The child is pulling on one end, and the weightlifters are pulling on the other end. Neither side will let go. As you might expect, the child is being taken for quite a ride. Which end of the scarf has the most tension? Explain why.

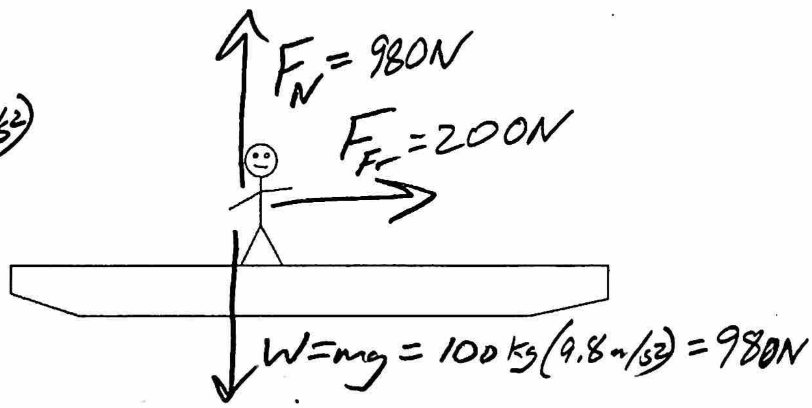
They're the same. Tension is the same at both ends of a string or scarf because the two pulls are an action/reaction pair.

4. A 100 kg human is standing on a barge <u>in the absence of air resistance</u>. The barge is accelerating to our right at a rate of $2 m/s^2$ and the person is accelerating along with it. Draw all of the **<u>individual</u>** forces that are acting on the **human**. Use arrows to show the direction of each force. Label each arrow with an appropriate **<u>name</u>** of the force, the **<u>correct magnitude of the force,</u>** and the **<u>correct units</u>**.

$\Sigma F = F_{Fr}$

$\Sigma F = ma = 100 kg (2 m/s^2) = 200N$

$F_{Fr} = 200N$



5. A 10kg watermelon is dropped out of an airplane without a parachute. Use the timetable to fill out the empty cells in the second data table below. Don't forget correct **signs and units.** The mass and weight columns will not be graded, but you might find them to be helpful.

Time	Event
0s	Watermelon is dropped out of plane
20s	Watermelon reaches terminal velocity of -100m/s
500s	Watermelon hits the Earth

Stays at terminal velocity for 480sec

Time	Watermelon Mass [not graded]	Watermelon Weight [not graded]	Force of Drag on melon	Net Force acting on melon	Melon Acceleration	Melon Velocity
0s	10kg	-98N	0N	-98N	-9.8m/s²	0m/s
15s	10kg	-98N	90N	-8N	-0.8m/s²	-80 m/s
80s	10kg	-98N	98N	0N	0m/s²	-100m/s

at T.V.

Downward forces

$\Sigma F = ma$
$-8N = 10kg(a)$
$a = -0.8 m/s^2$