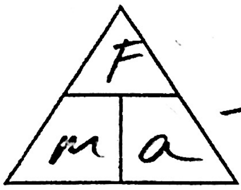
Physics 100 Name: Key

Notes and Practice: Newton's 2nd Law and Terminal Velocity

1. Newton's 2nd Law: $F_{net} = ma$ I often write F_{net} like this... ΣF "net force"

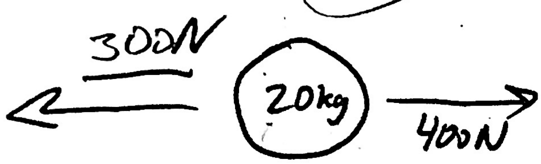
2. If you want, you can use an algebra triangle for F=ma.



$\Rightarrow \Sigma F = ma, \quad m = \frac{\Sigma F}{a}, \quad a = \frac{\Sigma F}{m}$

3. Use Newton's 2nd Law to fill in the missing values in these diagrams

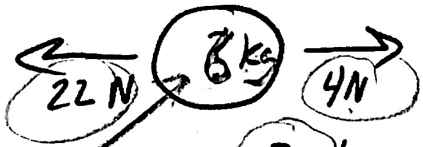
$\Sigma F = +100N$ ($\vec{\Sigma F} = 100N$)



$\vec{a} = 5 m/s^2$

$a = \frac{100N}{20kg} = 5$

$\Sigma F = -18N$



$a = -3 m/s^2$

$\frac{-18}{-3}$

4. Newton's 2nd Law can also be used to calculate weight. Since weight is the force of gravity, we can use F=ma with $10 m/s^2$ substituted in for acceleration. We usually write the weight formula like this...

$W = mg$ ← m: mass; g: acceleration of gravity

W: weight (force of gravity)

5. What is the weight of a 10kg block of ice, on Earth?

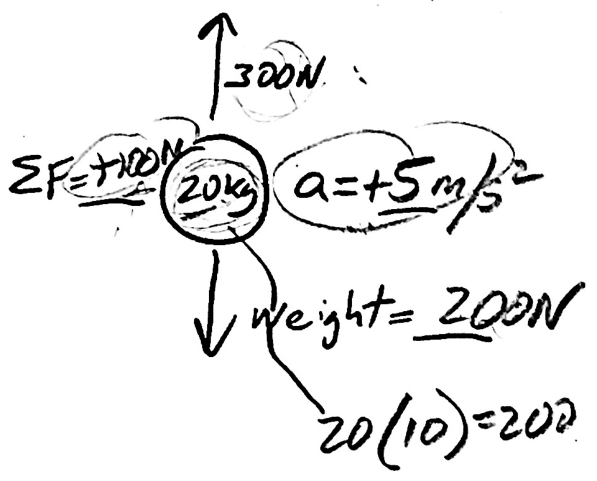
$W = mg$

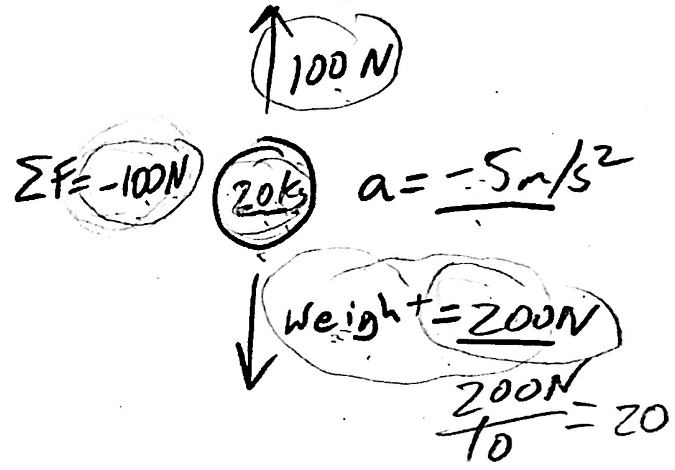
$W = (10kg)(10 m/s^2) = 100N$

$W = mg$ ($W = mg$; $m = \frac{W}{g}$; $g = \frac{W}{m}$)

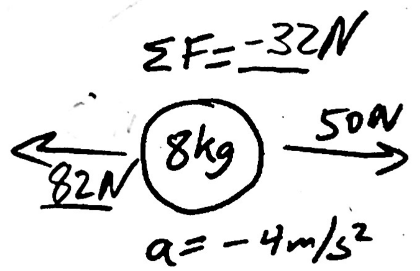
6. Use Newton's 2nd Law, and the formula for weight, to fill in the missing values in these diagrams.

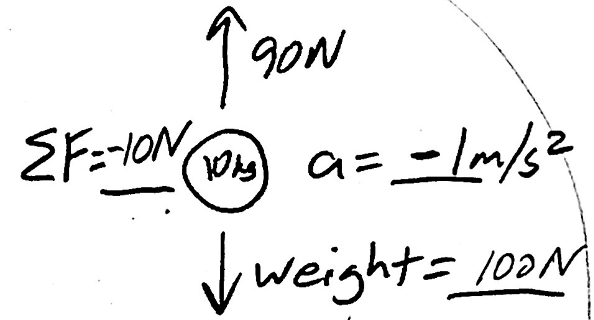
$\Sigma F = ma$ $m = \frac{\Sigma F}{a}$ $a = \frac{\Sigma F}{m}$

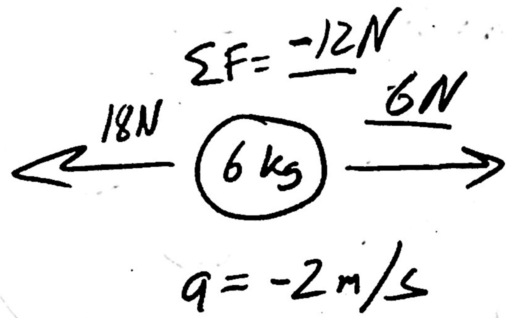


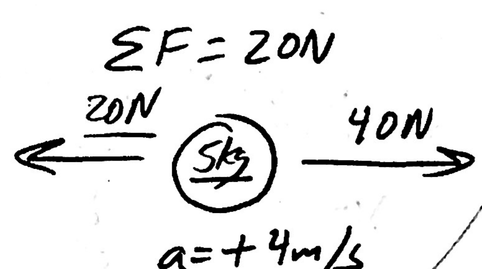


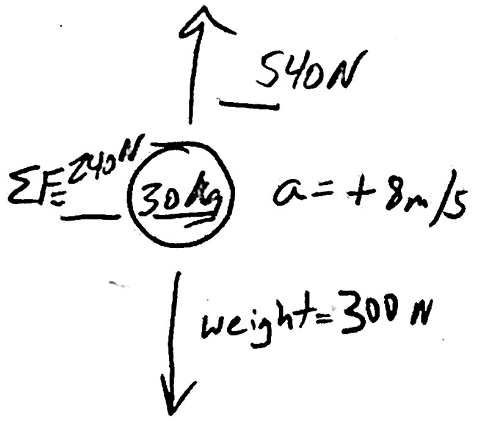
Practice Problems:

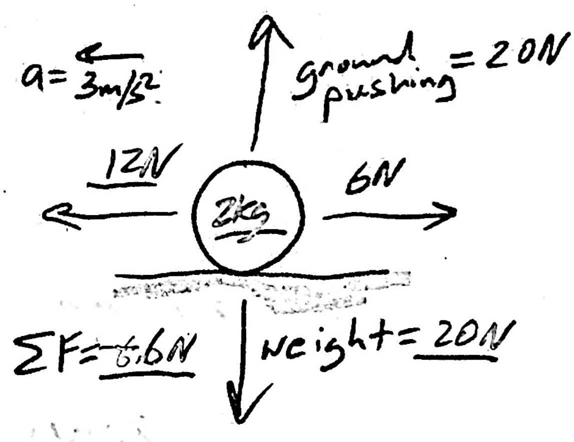








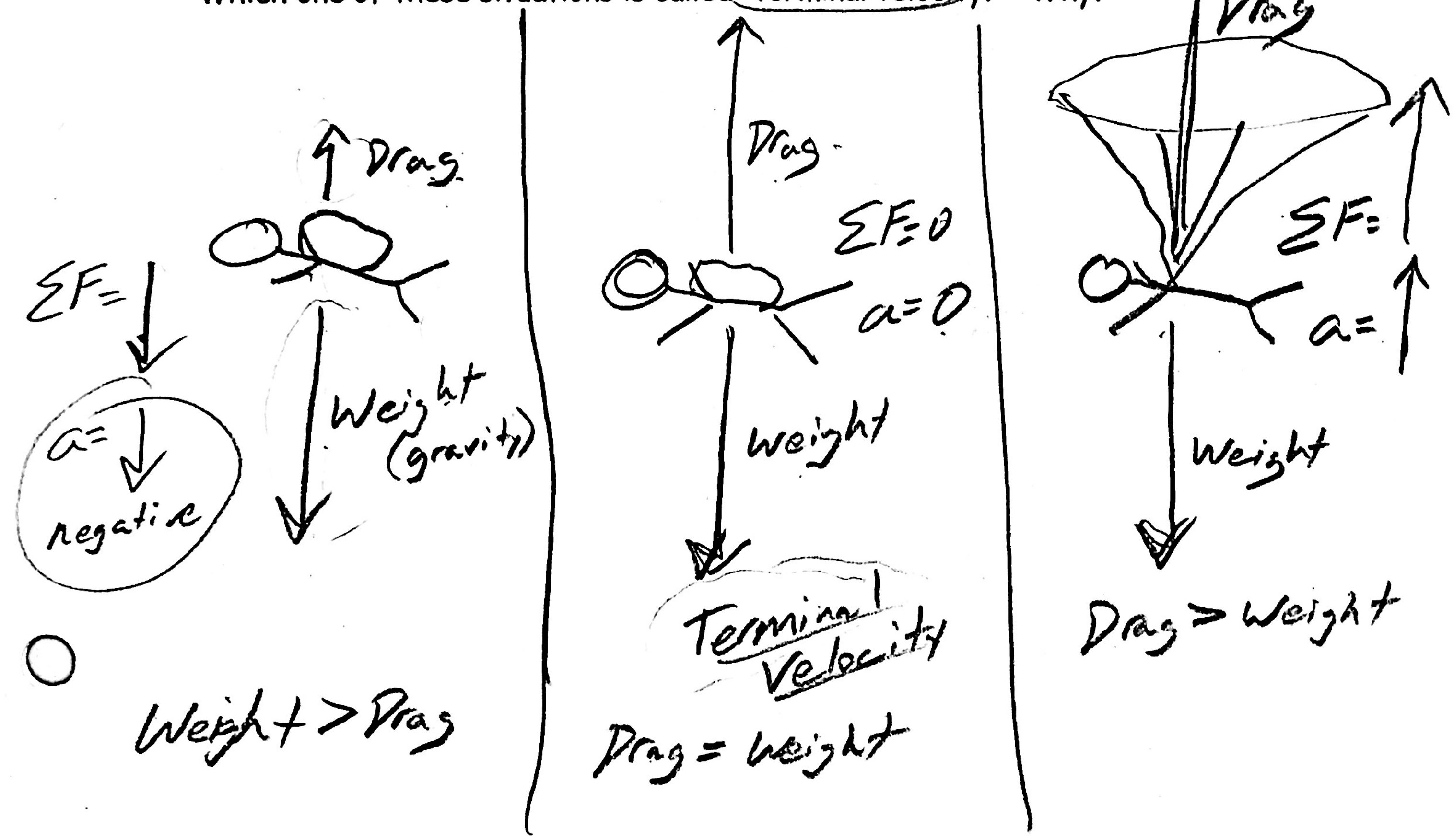




<u>Drag and Terminal Velocity:</u>

7. What is drag? A.K.A. Air resistance. A force exerted by air moving past an object.

8. Draw diagrams showing all of the forces acting on a skydiver in 3 different situations: negative acceleration, zero acceleration, and positive acceleration. Which one of these situations is called "terminal velocity?" Why?



The first table below provides information relating to a parachute jump. A parachuter steps out of an air plane, begins to fall, and subsequently reaches terminal velocity. After reaching terminal velocity, the parachute deploys her chute. The chute takes a few moments to open, and soon after that the parachute reaches a new terminal velocity. Minutes later, the parachute lands on the ground.

9. What happens to a falling object's velocity as it reaches terminal velocity?

Stops speeding up

10. Why does a falling object reach a terminal velocity?

Drag becomes as strong as weight

11. How and why does the act of a parachute opening her parachute affect her terminal velocity?

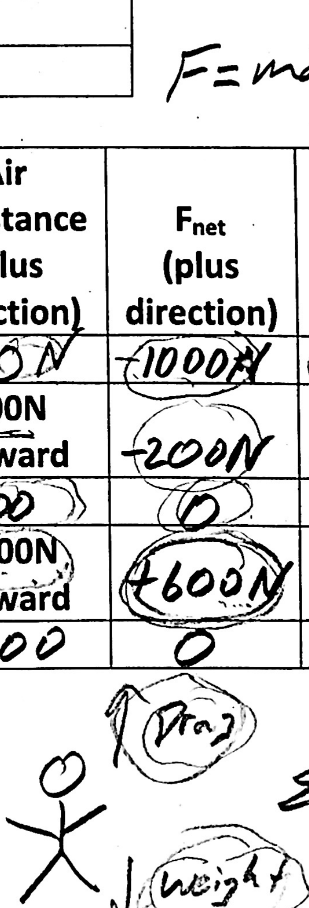
Slows her down → More drag

12. Use the provided data to fill in the table below. Include proper units!

Time	Event
0s	Parachuter steps out of plane
15s	Parachuter reaches a first terminal velocity of 60m/s
50s	Parachuter pulls chute cord. Chute deploys.
60s	Parachuter reaches a second terminal velocity of 7m/s
600s	Parachuter lands

$F = ma \quad m = \frac{F}{a} \quad a = \frac{F}{m}$

Time	Parachuter Mass (kg)	Parachuter Weight ($W=mg$)	Air Resistance (plus direction)	F_{net} (plus direction)	Acceleration (direction)	Speed
0s	100kg	-1000 N	0 N	-1000N	$-10\ m/s^2$	0
10s	100	-1000 N	800N Upward	-200N	$-2\ m/s^2$	45m/s
45s (T.V. 1)	100	-1000N	+1000	0	$0\ m/s^2$	60m/s
55s	100	-1000 N	1600N Upward	+600N	$+6\ m/s^2$	40m/s
150s (T.V. 2)	100	-1000N	1000	0	0	7m/s



$\Sigma F = \text{Drag} - \text{Weight}$

Terminal Velocity Practice: The first table, below, is a timeline detailing a parachuter's descent from an airplane. The second table is an incomplete analysis of mass, forces, and acceleration relating to the parachuter's fall. Use the timeline and your knowledge of physics to complete the second table. Pay close attention to the times in the second table. Most of them do not coincide with the times in the first table, but you can still use the first table to complete the analysis for those times. Before you go too far, it would be prudent to first identify the times in the second table at which the parachuter has reached terminal velocity.

Time	Event
0s	Parachuter steps out of plane
20s	Parachuter reaches a first terminal velocity of 45m/s
75s	Parachuter pulls chute cord. Chute deploys.
80s	Parachuter reaches a second terminal velocity of 4m/s
700s	Parachuter lands

Don't forget proper units!

Time	Parachuter Mass	Parachuter Weight	Air Resistance (plus direction)	F_{net} (plus direction)	Acceleration (direction)	Speed
0s	50kg	-500 N	0	-500N	$-10\ m/s^2$	0 m/s
3s	50kg	-500 N	100N Upward	-400N	$-8\ m/s^2$	20m/s
72s	50kg	-500 N	+500N	0N	$0\ m/s^2$	45 m/s
76s	50kg	-500N	1500N Upward	+1000N	$+20\ m/s^2$	40m/s
500s	50kg	-500N	+500N	0N	$0\ m/s^2$	4 m/s