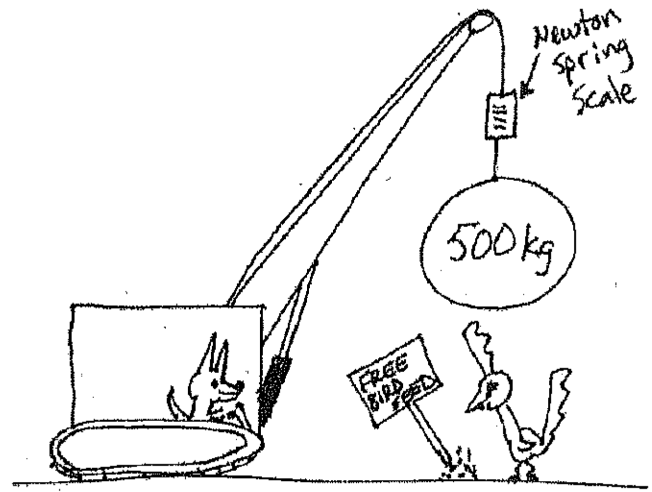
APPLICATIONS OF NEWTON'S 2ND LAW ANSWER KEY

Instructions: *Answer the following questions in your journal. Make sure to draw a FBD for each situation and show all of your work completely. Please indicate net force next to your FBD.*

1. A persistent coyote is trying to drop a wrecking ball on a pesky roadrunner! If the mass of the wrecking ball is 500. kg and it is hung from a spring scale **what does the scale read when the wrecking ball:**



a. ... is at rest
b. ... is accelerating downwards at 2.00 $^{m}/_{s^2}$
c. ... is accelerating upwards at 2.00 $^{m}/_{s^2}$
d. ... is being lifted at a constant rate of 1.00 $^{m}/_{s}$
e. ... is being lowered at a constant rate of 1.00 $^{m}/_{s}$

$m = 500\,kg$

F_T ↑ read by Spring scale

$F_g = mg$ ↓ ⤳ stays the same!

$= (500\,kg)(9.80\,m/s^2)$

$F_g = 49\bar{0}0\,N$

a. $V = 0 =$ constant ⤳ $a = 0$ ⤳ $F_{NET} = 0$

$F_T = F_g$

$\boxed{F_T = 49\bar{0}0\,N}$

b. $a = 2\,m/s^2$ ↓

$F_{up} = F_T = m(g-a)$ ⤳ From blue summary sheets

$= (500\,kg)(9.80\,m/s^2 - 2.00\,m/s^2)$

$\boxed{F_T = 39\bar{0}0\,N}$

c. $a = 2.00\,m/s^2$ ↓

$F_{up} = F_T = m(a+g)$

$= (500\,kg)(9.80\,m/s^2 + 2.00\,m/s^2)$

$\boxed{F_T = 59\bar{0}0\,N}$

d. $a = 0$ ($V = 1\,m/s =$ constant) ⤳ $F_{NET} = 0$

$F_T = F_g$

$\boxed{F_T = 49\bar{0}0\,N}$

e. $a = 0$ ⤳ $F_{NET} = 0$ ⤳ $F_T = F_g$

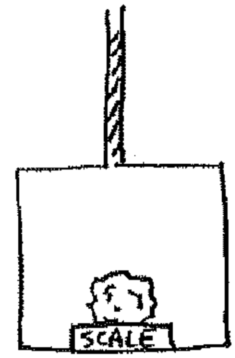
$\boxed{F_T = 49\bar{0}0\,N}$

2. A 20.0 kg rock is sitting on a bathroom scale in an elevator. **Fill in the blanks** for the following statements, but be sure to show all of your work completely!

a. The scale reads 236 N to cause an upward acceleration* 2.00 $^{m}/_{s^2}$

b. The scale reads 156 N to cause an downward acceleration* 2.00 $^{m}/_{s^2}$

*doesn't indicate the direction of movement of the elevator!



$m = 20.0 kg$

$F_g = mg$

$= (20.0 kg)(9.80 m/s^2)$

$F_g = 196 N$

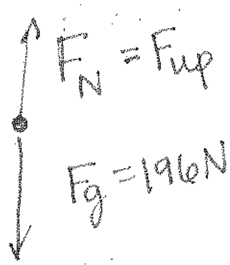
a. $a = 2.00 m/s^2 \uparrow$

$F_{NET} = ma = (20.0 kg)(2.00 m/s^2) = 40 N \uparrow$

$F_{NET} = F_N - F_g$

$F_N = F_{NET} + F_g = 40 N + 196 N$

$F_N = 236 N$



b. $a = 2.00 m/s^2 \downarrow$

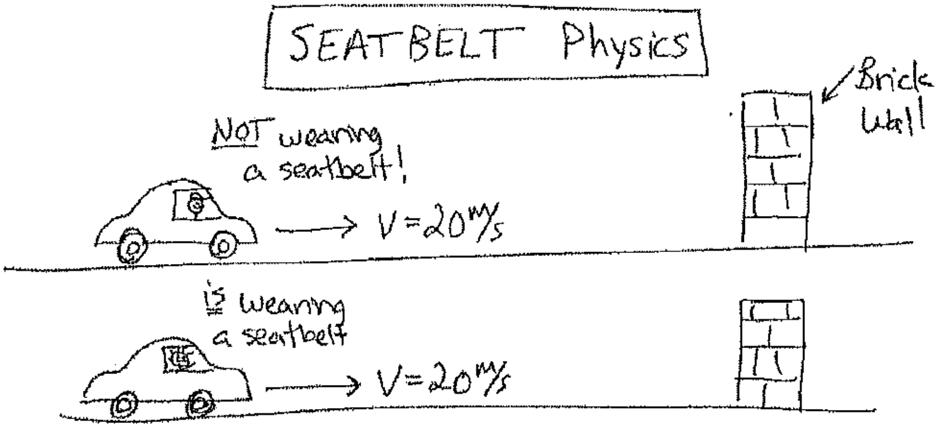
$F_{NET} = ma = 40 N \downarrow$

$-F_{NET} = F_N - F_g$

$F_N = F_g - F_{NET} = 196 N - 40 N$

$F_N = 156 N$

3. Jack and Jill have identical cars. Both have a mass of 60.0 kg and both are driving at 20.0 $^m/_s$ when they collide with identical brick walls.



Jack is not wearing a seatbelt, but Jill is. If it takes Jill 0.10 seconds to stop during the crash, but it only takes Jack 0.010 seconds, **compare the forces of impact** they experience.

$m = 60.0\ kg$

$V_1 = 20.0\ m/s$

$V_2 = 0\ m/s$

$t_{Jack} = 0.010\ s$

$t_{Jill} = 0.10\ s$

$F_{NET} = ? \Rightarrow a = ?$

$$a_{Jack} = \frac{V_2 - V_1}{t} = \frac{0 - 20.0\ m/s}{0.010\ s}$$

$$a_{Jack} = -2\bar{0}\bar{0}0\ m/s^2$$

$$F_{NET} = ma = (60.0\ kg)(-2000\ m/s^2)$$

$$\boxed{F_{NET(Jack)} = -1.2 \times 10^5\ N}$$

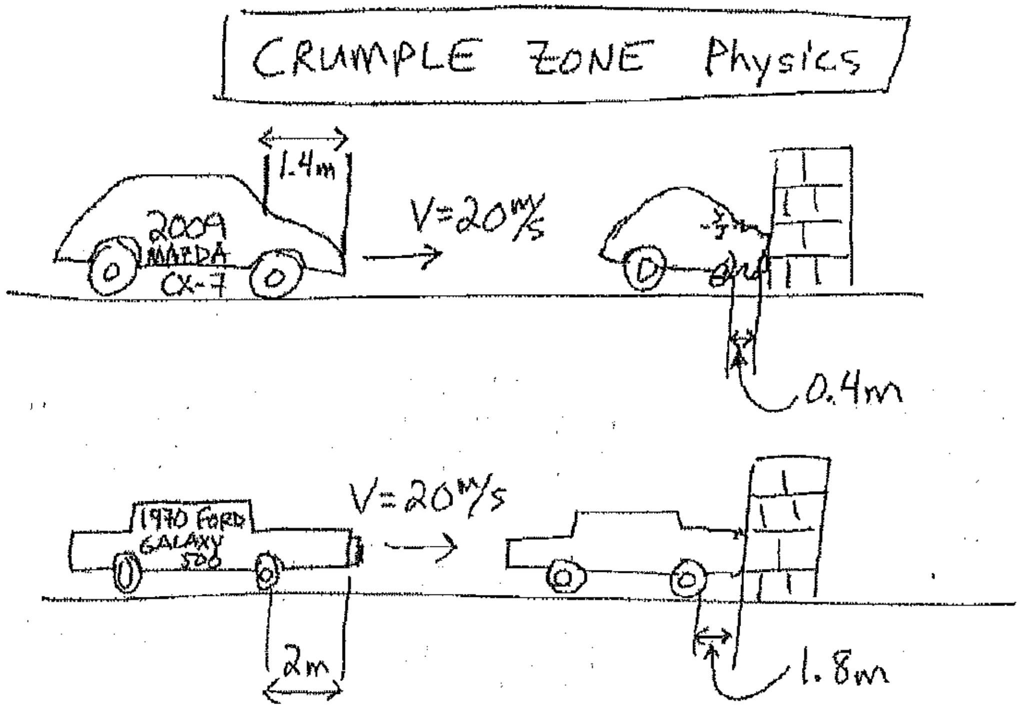
$$a_{Jill} = \frac{V_2 - V_1}{t} = \frac{0 - 20.0\ m/s}{0.10\ s}$$

$$a_{Jill} = -2\bar{0}0\ m/s^2$$

$$F_{NET} = ma = (60.0\ kg)(-2\bar{0}0\ m/s^2)$$

$$\boxed{F_{NET(Jill)} = -1.2 \times 10^4\ N}$$

4. A 2009 Mazda CX-7 and a 1970 Ford Galaxie 500 collide with a wall with an initial velocity of 20. $^{m}/_{s}$. The 2500 kg CX-7 has a crumple distance of 1.0 m during the crash. The 2500 kg Ford has a crumple distance of 0.20 m. **Compare the force of impact** on both cars during the crash.



$m = 2500\,kg$

$V_1 = 20.\ m/s$

$V_2 = 0\ m/s$

$d_{CX-7} = 1.0m$

$d_{Ford} = 0.20m$

$$V_2^2 = V_1^2 + 2ad \rightarrow a = \frac{-V_1^2}{2d}$$

$$a_{CX-7} = \frac{-(20.\,m/s)^2}{2(1.0m)}$$

$$a_{CX-7} = -200\ m/s^2$$

$$ma = F_{NET(CX-7)} = (2500kg)(-200\,m/s^2)$$

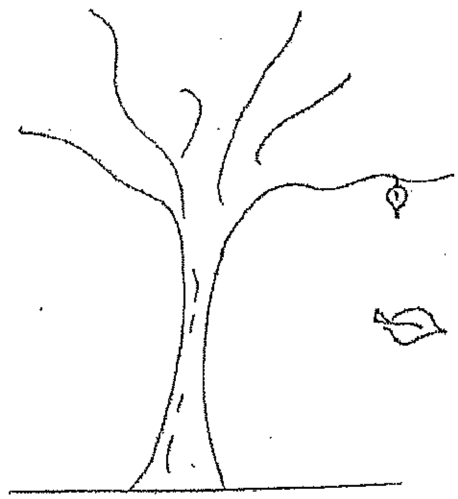
$$\boxed{F_{NET(CX-7)} = -5.0 \times 10^5\ N}$$

$$a_{Ford} = \frac{-(20.\ m/s)^2}{2(0.20m)} = -1000\ m/s^2$$

$$F_{NET} = ma = (2500kg)(-1000\,m/s^2)$$

$$\boxed{F_{NET(Ford)} = -2.5 \times 10^6\ N}$$

5. A 0.50 g leaf falls to the ground at a constant downward velocity of 1.00 $^{m}/_{s}$.



$m = 0.50 g$
$= \underline{0.0005 \text{ kg}}$!

a. Calculate the upward **force of air drag** acting on the leaf.
b. Draw a **quantitative FBD** of the leaf.

a. $V = 1.00 \, m/s = \text{constant} \rightsquigarrow \underline{a = 0}$

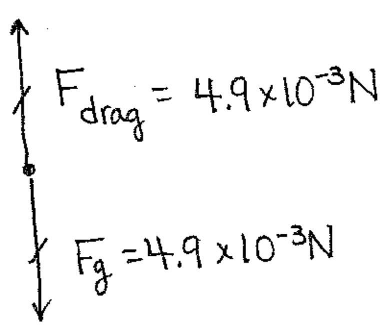
$F_{NET} = 0 = F_{drag} - F_g$

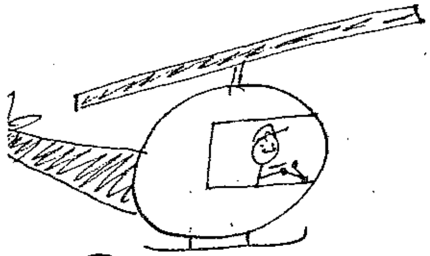
$F_{drag} = F_g = mg$

$= (0.0005 \text{ kg})(9.80 \, m/s^2)$

$\boxed{F_{drag} = 0.0049 \text{ N}} = 4.9 \times 10^{-3} \text{ N}$

b.





HELICOPTER!!

6

A rescue helicopter, mass 900 kg, is taking off from a heli-pad. Initially, the rotors pushing against the air provide a lift of 9450 N.

a) What is the acceleration of the helicopter?

b) After 5 seconds, how fast is the helicopter moving upwards?

c) How much lift must the rotors provide to make the helicopter continue upwards at a constant speed (the speed described above)?

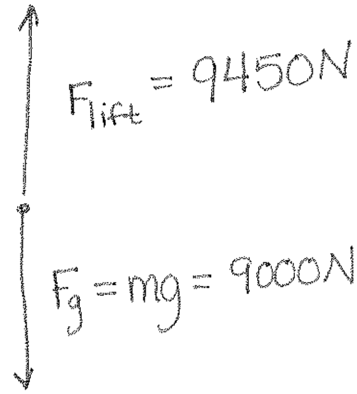
d) The helicopter uniformly slows to a stop so it can hover. This slowing takes 2 seconds. What is the lift during this time?

e) The helicopter is hovering. Lift = ?

f) The helicopter suddenly drops a load of supplies. At that moment, the pilot has to reduce the lift of the helicopter to 8000N so that it remains motionless after the drop. What was the mass of the load?

⑥ $m = 900\,kg$

$F_{lift} = 9450N$



$F_{NET} = 450N$ up!

a) $a = ?$

$F_{NET} = ?$

$a = \frac{F_{NET}}{m} = \frac{450N}{900\,kg}$

$\boxed{a = 0.5\,m/s^2}$ up!

b) $t = 5s$, $V_2 = ?$

$V = at \qquad a = \frac{V_2 - V_1^{\,0}}{t} \Rightarrow V_2 = at$

$= (0.5\,m/s^2)(5s)$

$\boxed{V_2 = 2.5\,m/s}$

c) $F_{lift} = ?$ $\quad V = \text{constant}?$

$\boxed{F_{lift} = 9000N}$

e d) hovering? $\boxed{F_{lift} = 9000N}$

d e) $t = 2s \qquad a = \text{constant} \qquad V_2 = 0\,m/s \qquad F_{lift} = ?$

$V_1 = 2.5\,m/s$

$F_{NET} = ma = m\left(\frac{V_2 - V_1}{t}\right) = 900kg\left(\frac{0\,m/s - 2.5\,m/s}{2s}\right)$

$F_{NET} = -1125N$ (down)

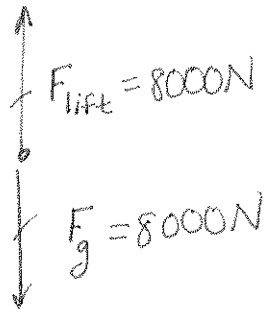
$F_{NET} = F_{lift} - F_g \Rightarrow F_{lift} = F_{NET} + F_g = (-1125N) + (9000N) = \boxed{7875N}$

f) $F_{lift} = 8000N$, $v = 0$

$a = 0$

$F_{NET} = 0$

$m = ?$



change in $F_g \Rightarrow \frac{1000N}{10 m/s^2}$

$\boxed{m = 100kg}$